# HARVEST'S COOK INLET PIPELINE (CIPL) EXTENSION PROJECT ACOUSTIC MONITORING

Final report. April 2019


## Summary

Harvest Alaska, a subsidiary of Hilcorp, installed two subsea oil and gas pipelines within Cook Inlet beluga whale critical habitat, between May and September 2018. NMFS was interested in characterizing the underwater noise generated by these activities to inform management decisions in future projects, and reduce assumptions related to the potential acoustic disturbance to endangered marine mammal species. A passive acoustic mooring package was deployed 1 km north of the pipeline corridor for 128 days during construction. A total of 6 noise sources were identified and linked to the construction activities, plus an unknown source of mechanical machinery. Results demonstrate that, during pipe pulling from a winch barge, winch noise and pipeline drag generate tonal and impulsive signals, but broadband vessel noise was the primary source of acoustic disturbance. Vessels noise was broadly distributed in time and space, instead of being concentrated in periods corresponding to operations along the closest section of pipeline path to the acoustic mooring. An unexpected source of noise, likely originated by the anchor buoy lines at high current periods, provided the highest sound pressure levels (SPL) with a median of 144.7 dB re 1 µPa for the frequency range of 20 Hz to 24 kHz. When considering the full construction period, the frequency range of highest disturbance was 20 Hz to 5400 Hz. Overall SPL ranged from 86 to 137 dB, and 31.1% of the sampled time SPLs exceeded the level B harassment threshold of 120 dB. These results demonstrate the IHA analysis was conservative the majority, but not all, of the time and potential harassment was adequately characterized. When concurrent acoustic and visual efforts were compared, all days with beluga whale sightings included acoustic detections except 3 (2.3 %), while 28 days (21.3%) with beluga acoustic detections did not include visual sightings. Maximum acoustic detection range from the mooring was estimated at 6.7 km for vocalizations and 2.4 km for echolocation.



Manuel Castellote

Joint Institute for the Study of the Atmosphere and Ocean, University of Washington & Cetacean Assessment and Ecology Program, Marine Mammal Laboratory. Alaska Fisheries Science Center, NOAA Fisheries

manuel.castellote@noaa.gov


JISAO

Joint Institute for the Study of the Atmosphere and Ocean

# Contents

1. Background ..... 2
2. Methods ..... 2
3. Results ..... 4
3.1 Mooring deployment ..... 4
3.2 Overall noise levels ..... 4
3.3 Specific noise sources ..... 11
3.3.1 Vessel noise ..... 13
3.3.2 Unknown ..... 15
3.3.3 Pipe pulling impulsive ..... 17
3.3.4 Pinger 20 kHz ..... 19
3.3.5 Pipe pulling tonal ..... 21
3.3.6 Impulsive sequence ..... 23
3.3.7 Aircraft ..... 25
3.4 Source level calculations ..... 27
3.5 Comparison of beluga visual sightings with acoustic detections ..... 32
3.6 Harbor porpoise detections ..... 34
4. References ..... 35

# 1. Background

Harvest Alaska, a subsidiary of Hilcorp, installed two pipelines in Cook Inlet from Ladd Landing to the Tyonek Platform between May and September 2018. The project required the presence and operation of multiple vessels including two tugs, dive boat, sonar boat, work boat, crew boat and a winch barge. Installation included removing obstacles in the pipeline corridor using a tug, digging a trench to bury the pipeline in the intertidal/transitional zone, pulling the pipelines into place using a winch mounted on a barge, moving a barge outfitted with six anchors up to 3 times/day, stabilizing the pipelines, running sonar surveys to make sure the pipeline was in the right place, use of dive and other support boats, connecting the natural gas pipeline to the Tyonek platform and capping the oil pipeline.

There is a paucity of passive acoustic data for activities involved with the project. NMFS is interested in obtaining this type of acoustic data to inform management decisions in future projects, and reduce assumptions related to the potential acoustic disturbance to endangered marine mammal species.

The area off Ladd Landing is part of the ook Inlet beluga critical habitat. This area has not been monitored for beluga presence other than by NMFS aerial surveys. Passive acoustic monitoring in this area is beneficial not just to document to acoustic footprint of the pipeline activities, but also to better understand beluga seasonal occurrence in this region of the critical habitat.

The purpose of the study was to identify the acoustic footprint of the pipe-laying operations compared to baseline background noise levels, relationship to tide; identify and describe the acoustic characteristics of noise sources from the different modes of operation. Calculation of propagation loss was planned using near source dipping hydrophone recordings, unfortunately these recordings where unusable due to wrong recorder configuration. However, several sources of noise were identified from the winch barge operation, and the approximated location of the barge was used to estimate source levels.
Mooring recordings and echolocation logs have also been used to identify beluga presence and absence, and a comparison analysis has been completed with visual efforts by Fairweather.

# 2. Methods

An acoustic mooring consisting of an acoustic recorder (DSG-ST, Loggerhead Instruments) sampling at 48 kHz on a duty cycle of 4 minutes every 7 stand-by minutes (36.4 %), an echolocation logger (C-POD v1 Chelonia Ltd.), an acoustical release (PORT-LF, Edgetech), an Onset HOBO temperature and depth sensor, and a subsurface float package (Castellote *et al*. 2016) was deployed 1005 m away from the pipe path approximately 1.3 nm from shore, within the visual effort grid (Fig 1).

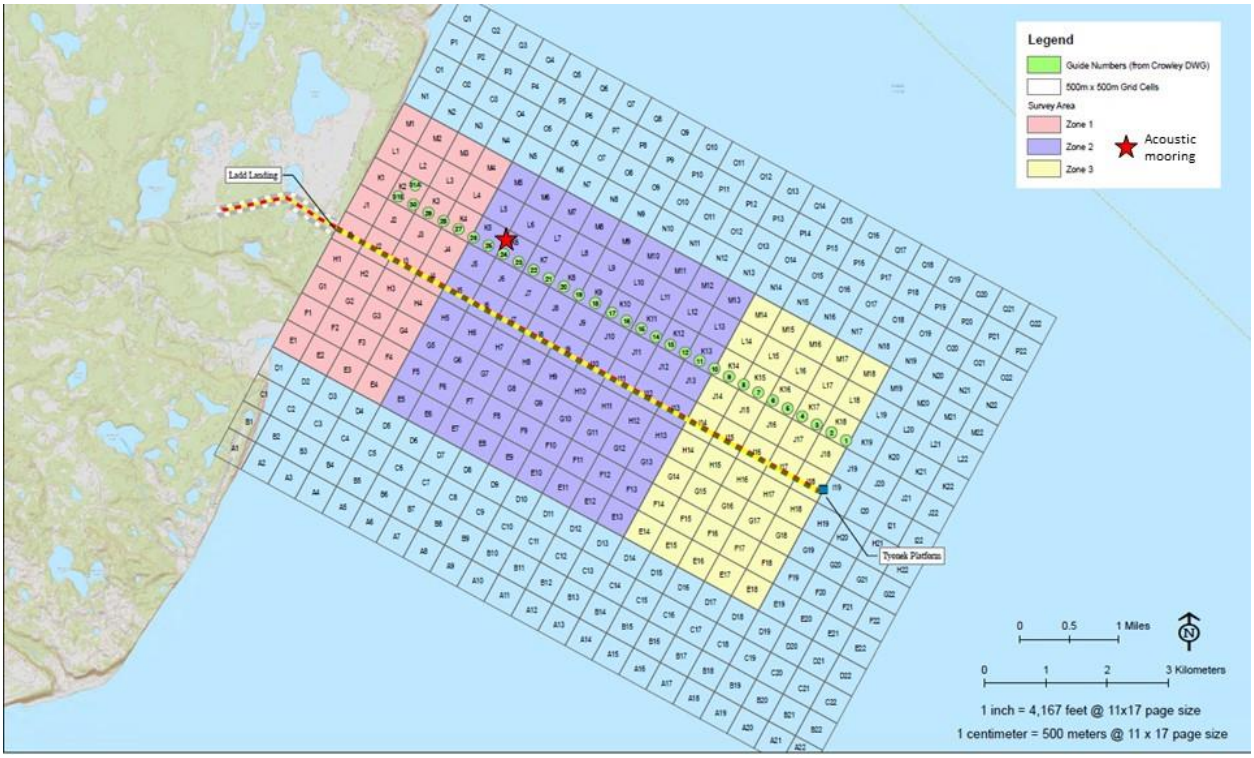


Figure 1: Visual effort grid, pipe path and acoustic mooring location

Data analysis was completed using custom written Matlab scripts to calculate, on an hourly basis, spectral probability density and 1st, 5th, 25th, 50th (median), 75th, and 99th percentile spectra (in dB re 1 $\mu Pa^2/s$), and broadband sound pressure level (SPL) in RMS dB re 1µ Pa. Matlab based Triton software v1.93 was used to identify and log anthropogenic noise events. Received levels of specific noise sources were calculated using the start and end time of these events. SPL was calculated on a 1 s resolution for 20 Hz to 24 kHz to obtain received levels of these noise sources, using practical spreading to calculate propagation loss. Appendix F of the visual effort 90-day report (Sitkiewicz *et al*. 2018) was used to identify the operational context of when noise events occurred. GPS locations of the vessel "Sand Island", operating side scan sonar when the pipe was being pulled by the winch barge, was provided by Fairweather as a proxy of the barge location to estimate distances of the noise sources to the acoustic mooring.

Data was also processed using Pamguard v2.0 automatic detectors to identify beluga calls and whistles. C-POD software v. 2.044 was used to process echolocation logs and identify beluga and porpoise detections. All beluga and porpoise automatic detections where manually validated, to confirm no false detections where included in further analysis. Validated porpoise and beluga detections were compared to visual effort results. Concurrent visual sightings and acoustic detections were used to calculate acoustic detection range of beluga signals.

# 3. Results

## 3.1 Mooring deployment

Initial mooring deployment was made by Fairweather on May 5th 2018 at N61° 6' 36" W151° 3' 36" (datum: NAD83) at a distance to the pipe path of 342 m. Hilcorp determined this distance was too close to the pipe path, therefore the mooring was relocated on May 15th to N61° 6.691' W151° 2.859' (WGS84), at a distance of 1005 m from the pipe path, as initially planned. Mooring was recovered on September 13th 2018.

## 3.2 Overall noise levels

To obtain overall results, several high pass cutoff frequencies were tested to evaluate the effect of flow noise by high current periods (Fig. 1). Flow noise affects low frequencies, generally below 100 Hz, overlapping with the frequency bands of highest vessel noise contribution. It was difficult to determine if the relationship between received levels and tide was due to an increase in general background noise from natural sources (e.g., sediment transport, surface waves), or due to an increase in flow noise around the hydrophone capsule. The mooring package angle data suggested flow noise might have contributed at peak current periods. Therefore, a high pass cutoff frequency of 20 Hz was applied to all the analyses.

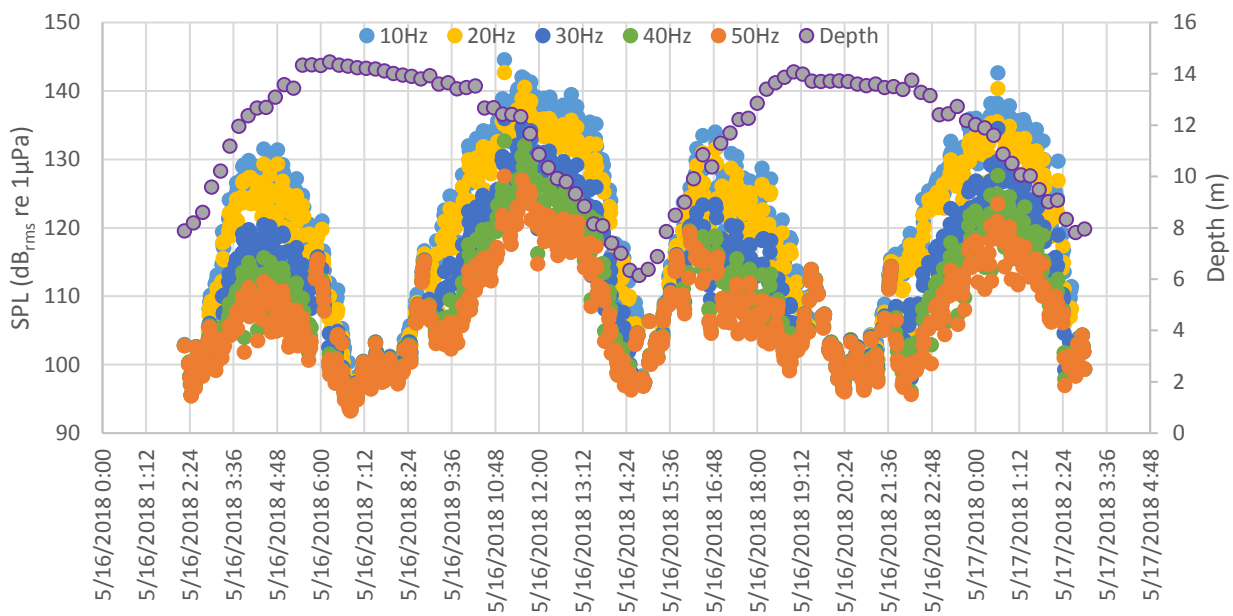



Figure 1: Time series from 5/16/18 at 00:00 to 5/17/18 at 03:00 showing depth at the mooring site for 2 tidal cycles and its corresponding SPL values per minute, for 5 different high pass cutoff frequencies, 10, 20, 30, 40 and 50 Hz. The figure shows how SPL increases during flooding, and specially ebbing, and how SPL gets to a minimum during high and low slack times.

A 20 Hz high pass cutoff reduces flow noise but does not eliminate it as seen in Fig. 1. Higher frequency cutoff would further reduce the unwanted effect of flow noise but would compromise reliability in received level measurements as it would filter out acoustic energy from the sources of interest. Because most sources of noise of interest for this study predominate low frequencies, including those above 20 Hz, it was decided to avoid a higher frequency cutoff. This was determined to be a good compromise between flow noise reduction and low impact to the acoustic energy from sources of interest. Data was analyzed to obtain SPL in RMS dB re 1µPa for 20 Hz to 24 kHz, averaged over 1 hour period, for the entire deployment period (Fig. 2):

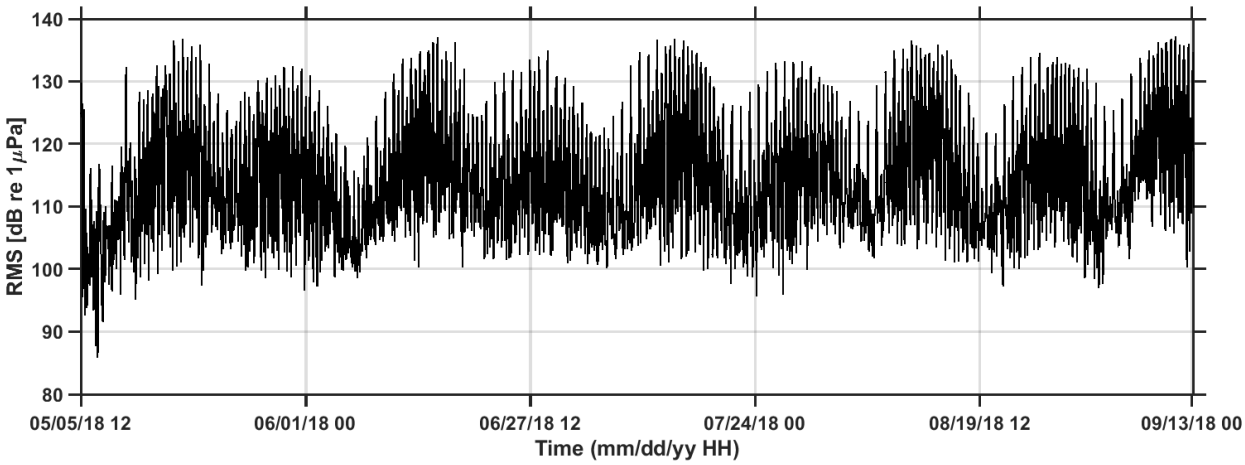



Figure 2: sound pressure levels (SPL) in RMS dB re 1µPa for the frequency range of 20 Hz to 24 kHz, averaged over 1 hour period, for the entire deployment period (5/5/18 – 9/13/18). Both the diel tidal cycle and the spring and neap monthly tidal variation are reflected in the SPL trend.

SPL ranged from 85.9 dB to 137.2 dB, with a median of 113.1 dB and average of 114.8 dB (S.E. = 0.2 dB). The NMFS harassment threshold (level B take) of 120 RMS dB was exceeded at the mooring location for 31.1% of the time, the 125 RMS dB threshold, sometimes applied in upper Cook Inlet, was exceeded 17.1 % of the time. During the IHA issuance process, NMFS estimated noise levels of 120 dB would extend 2.7 km from the pipeline corridor. Assuming practical spreading (i.e., 15log(r)), received levels would have to be >126.5 dB at the mooring location to exceed the 120dB at 2.7km isopleth. Received levels exceeded 126.5 dB 14.8% of sampled time. Table 1 presents further equivalence of percentiles and SPL values.

Table 1: Percentiles, based on total deployment duration (5/5/18 – 9/13/18), for SPL values in RMS dB re 1µPa for the frequency range of 20 Hz to 24 kHz, averaged over 1 hour period.

| **Percentile** | **SPL (RMS dB re1µPa)** |
|---|---|
| 95th | 101.6 |
| 75th | 107.3 |
| 50th | 113.1 |
| 25th | 122.2 |
| 5th | 132.1 |

The initial 4 days of deployment were supposed to be used as baseline noise conditions because the operations did not started until 5/9/18, although the vessels involved in the pipe laying operation were already mobilized to the area by the time of deployment. Fig. 2 shows how in general, SPLs are lower for that initial period, gradually increasing until the spring tides by 5/15/18. However, when the mooring was relocated on 05/15/18, it was found that a shackle and swivel were placed on the top attachment point of the release, likely to be used to facilitate lowering the mooring to the sea bottom (Fig. 3). This hardware, once the mooring was deployed, was loose hanging on top of the release, and rattled against the release transducer almost constantly with the current flow. A close inspection of the data confirms the rattling noise was recorded in the data from the deployment day 5/5/18 until the relocation day 5/15/18, (Fig. 3), thus limiting the validity of this recording period to be analyzed for baseline noise conditions. Furthermore, it seems the release was not switched to sleep mode once the package was deployed on 5/5/18, and the rattling against its transducer triggered the release to ping repeatedly until the mooring was relocated and the release was switched to sleep mode on 5/15/18.

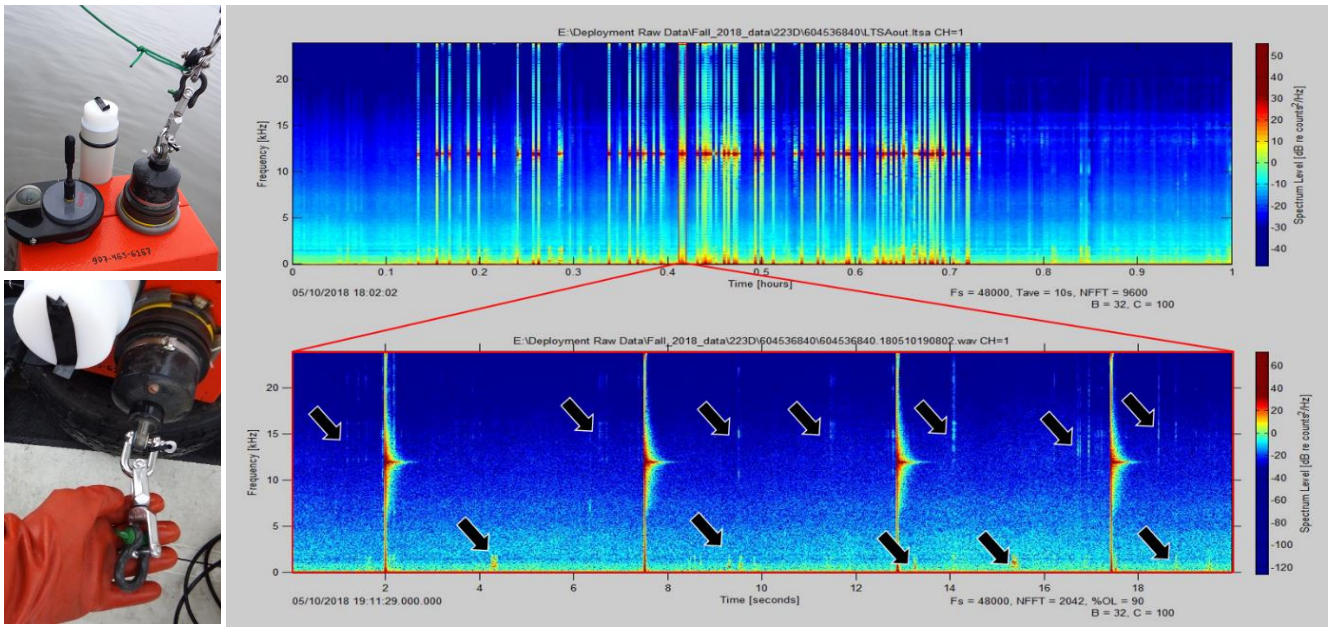



Figure 3: (Left) images of the mooring package while being relocated, showing a shackle and swivel attached to the top release frame, which produced rattling noise with the currents and triggered the acoustical release to ping repeatedly. (Right) long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 20 s spectrogram (lower panel) of a section of the long-term spectrogram from 5/10/18 showing the rattling noise indicated by black arrows, and the 12 kHz triggered ping from the release. A piece of electrical tape on the C-POD transducer is visible in the image, which was also removed during relocation.

A selection of data, from 5/5/18 at 5pm to 5/10/18 at 5am was used as the period of best baseline noise conditions available within the dataset, considering the limitations described above. This included 8.5 tidal cycles ranging from 5.5 m to 11.2 m in mooring depth. The distribution of acoustic energy across frequencies for this baseline period is represented in a spectral probability density (SPD) plot (Merchant *et al*. 2013), calculated in 1 h bins for the baseline noise conditions period, and its corresponding spectral percentiles (Fig. 4).

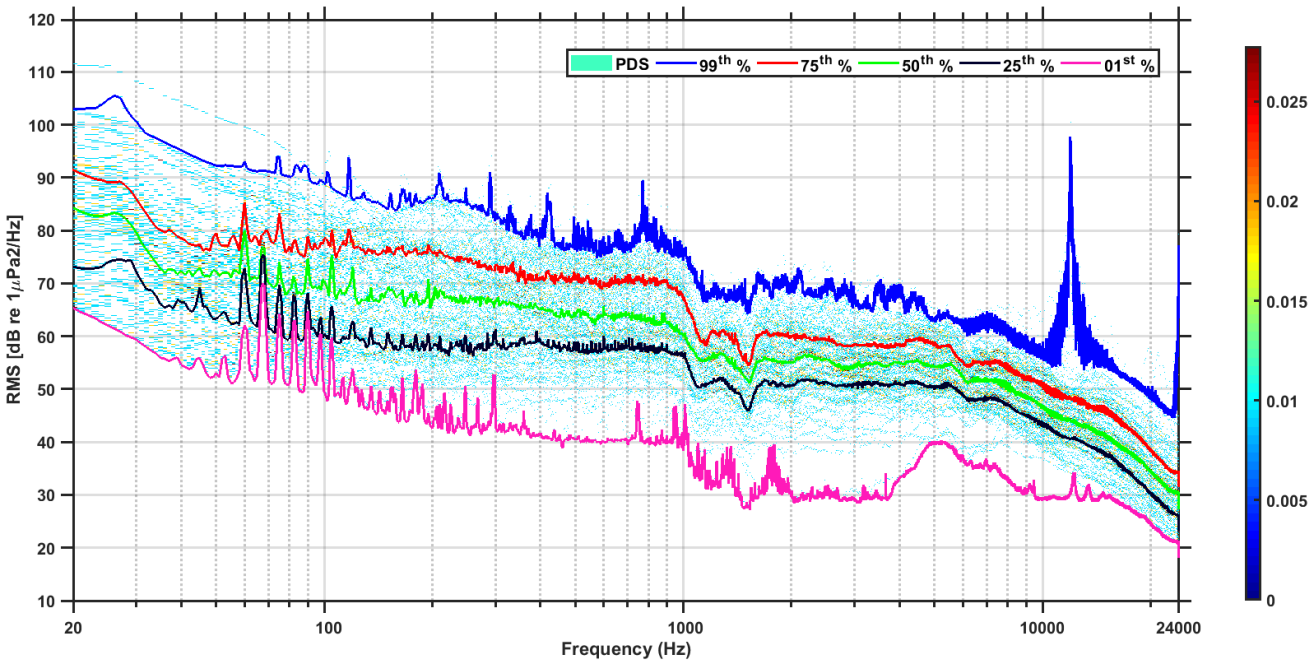



Figure 4: Spectral probability density plot, for 20 Hz to 24 kHz, in dB re 1 µPa2/Hz, calculated in 1 h bins, and spectral percentiles 1st to 99th, for the baseline noise conditions period (5/5/18 – 5/10/18).

Figure 4 highlights a relatively constant decay in acoustic energy from low to high frequencies. The spike at 12 kHz is related to the mooring release pings, triggered by the hardware left attached to the top of its transducer. The wideband rattling noise affected multiple frequency bands, and is reflected by a bump in the 99th percentile curve at 200 Hz - 1500 Hz, and a bump in the 5 kHz to 7 kHz depending on the percentile curve, confirming this has biased the characterization of baseline noise conditions, at least for these frequency ranges.

A SPD plot, in 1 h bins, was also calculated for the rest of the deployment period, from 5/10/18 to 9/13/18, and its corresponding spectral percentiles (Fig. 5). The plot highlights the wide variability in acoustic energy due to the combination of vessel noise and tidal influence in frequencies up to approximately 100 Hz. Because this acoustic energy is spread across a limited frequency range in the lower end of the spectrum, rarely exceeding 100 Hz, we do not expect this variability to influence the reported received levels of the diverse sources of noise in this report. In particular, the high amplitude and wideband nature of most of the noise sources would balance out the influence of this band-limited variation. For the narrow-band sources (i.e., pingers) these occurred at much higher frequencies than 100 Hz, and thus outside the range of possible influence by this variability in the background noise.
The spike at ~120 Hz is of unknown origin, but could be related to vessel engine noise, as this was a very prevalent source. Small spikes at 19.5 kHz and 20.5 kHz correspond to a 20 kHz pinger discussed below.

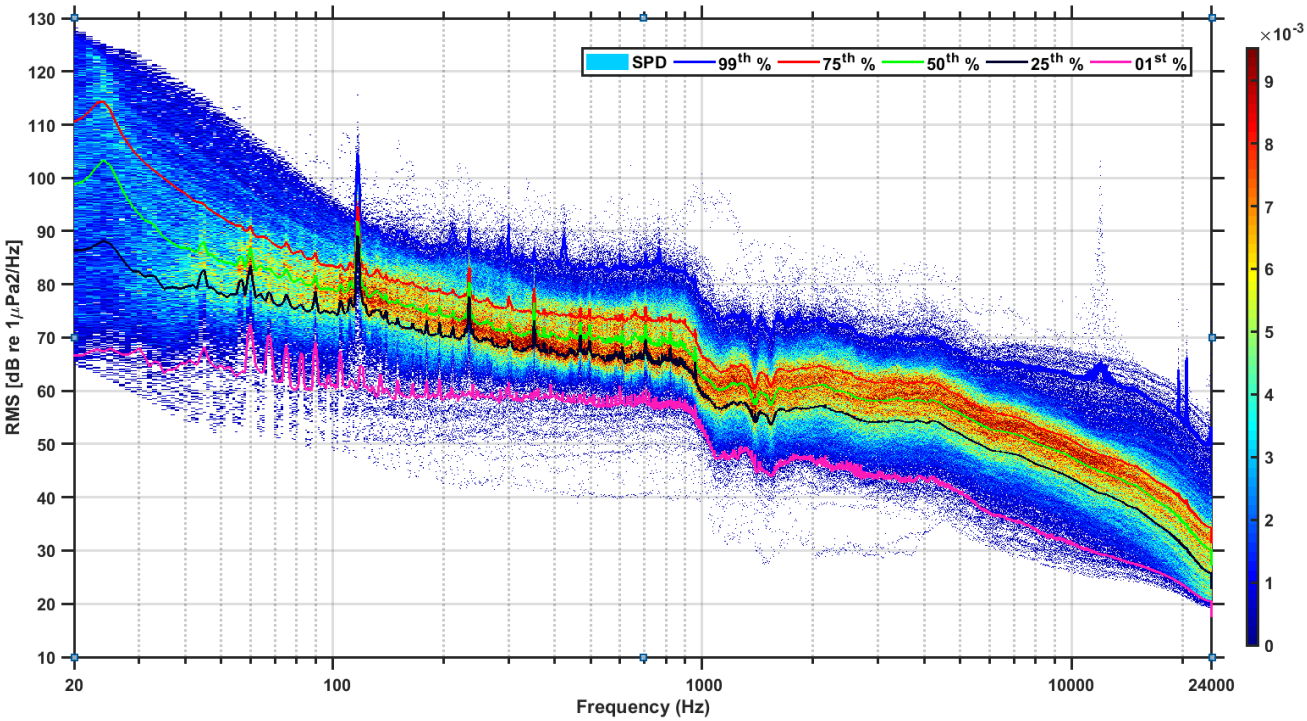



Figure 5: Spectral probability density plot, for 20 Hz – 24 kHz, in dB re 1 μPa$^2$/Hz, calculated in 1 h bins, and spectral percentiles 1$^{st}$ to 99$^{th}$ , for the deployment period except the baseline noise conditions period (5/10/18 – 9/13/18).

The 50th percentile spectra for both the baseline noise conditions and the rest of the deployment period were compared to highlight the overall pipe-laying project acoustic footprint and presented in Fig. 6. The comparison highlights the main differences in median levels of noise across frequencies occurring up to 5400 Hz. Above that frequency, differences are minimal. Maximum differences between curves reached 22.3 dB at 137 Hz.

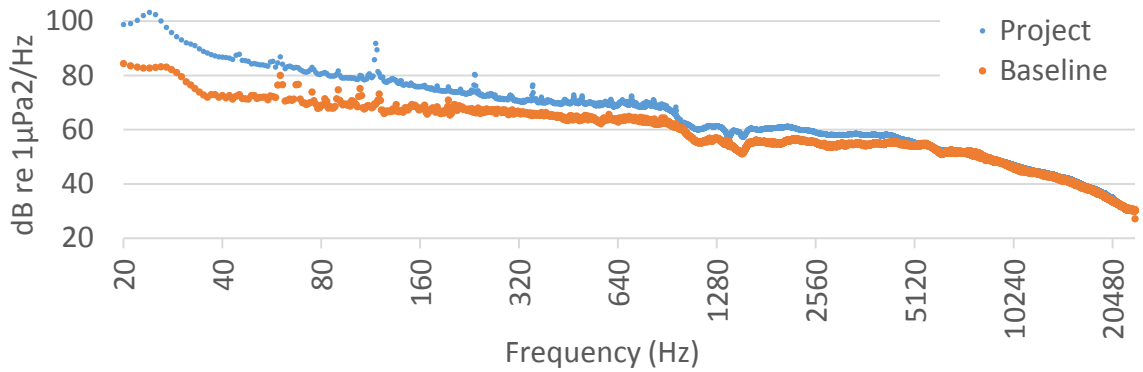



Figure 6: Comparison of the 50th percentile spectra for the baseline noise conditions (orange series, 5/5/18-5/10/18) and the rest of the deployment period (blue series, 5/10/15-9/13/18), obtained at 1 Hz resolution analysis.

A long-term spectrogram average was calculated to evaluate the overall distribution of noise contributors over the deployment period (Fig. 7). In general, vessel noise is present ever day without an evident period of higher amplitude noise, as it would have been expected for the days when the pipe pulling barge was operating closer to the mooring site. Only by the end of the deployment period, from 9/8/18 to the end of the deployment period (9/13/18), the amplitude is slightly elevated in the 20 Hz – 6 kHz range. Closer inspection of this period suggests the increase is due to higher intensity of vessel noise. A shorter period of high amplitude peaking at 12 kHz is observed on 5/15/18 related to the mooring relocation that occurred that day. A pinger signature can be sporadically observed at 19.5 kHz and 20.5 kHz from 5/16/18 to 9/13/18.

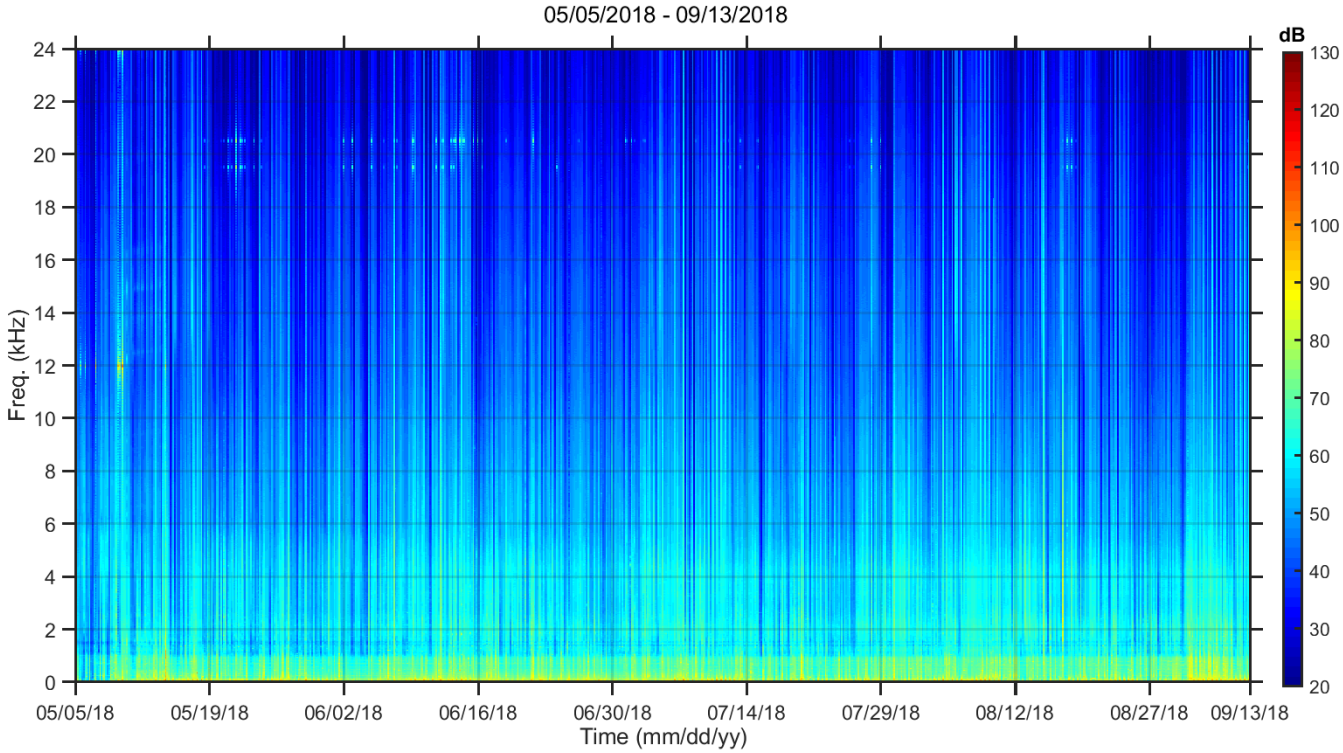



Figure 7: Long-term spectrogram average for the entire deployment period (5/5/18 – 9/13/18), for 20 Hz to 24 kHz.

When the long-term spectrogram average plot (Fig. 7) was compared to the tidal fluctuation over the sampled period (Fig. 8), no obvious relationship was found between the days with highest tidal exchange (i.e. spring tides) and days of highest overall acoustic amplitude. IF a relationship existed. Periods of highest tidal exchange would match periods of highest overall acoustic amplitude, or at least higher amplitude at the lower frequency spectrum (due to a combination of increased background noise by the stronger currents and flow noise at the hydrophone).

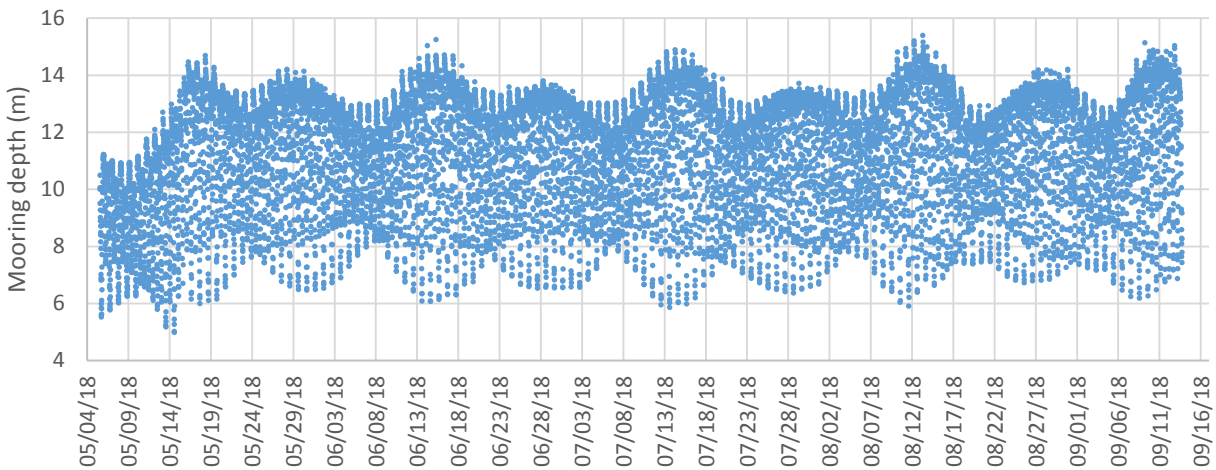



Figure 8: Mooring depth based on the pressure sensor for the entire sampled period. Note hoe the depth regime shifts to deeper waters after 5/15/18 when the mooring was relocated further away from the pipe path. The minima observed on 5/15/18 corresponds to the time the mooring was at the surface or on deck until relocated.

## 3.3 Specific noise sources

Classification of anthropogenic events was made manually by playing and inspecting the spectrogram of each signal. A classification scheme was made with printed spectrograms and wav clips used as reference for comparison. Only undoubtful events were assigned to known noise source classes, and all doubtful events were classed under the unknown class to minimize error. Only noises that were clearly from anthropogenic origin were included in the analysis. A total of 6 noise sources were identified (Table 2) plus an unknown source of mechanical machinery. Because multiple concurrent vessels were operating in the area, an aggregated combination of vessel noise was continuous in the recordings. Figure 3 shows vertical light blue lines across the deployment duration, these are all vessel noise events. The recognition of specific noise signatures was challenging due to the continuous vessel noise in the background.

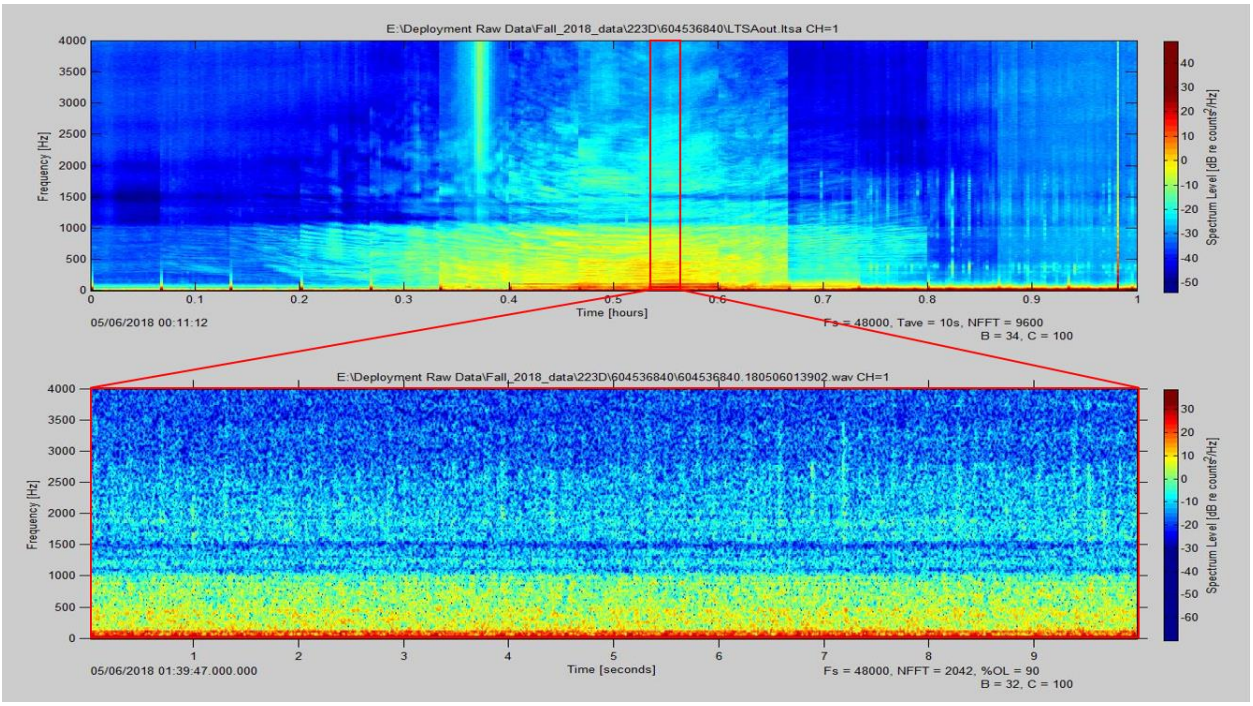
Table 2: Noise sources identified in the recordings based on specific sound signatures observed in the spectrogram, number of events, total time logged per class, and mean event duration per class. Nosie sources are ordered from highest to lowest total time.

| Noise class | # events logged | total time | Mean event duration |
|---|---|---|---|
| Vessel noise | 24 | 3045h 14 m | 13h 40m |
| Unknown | 68 | 260h 31m | 4h 11m |
| Pipe pulling impulsive | 90 | 105h 46m | 1h 26m |
| Pinger 20kHz | 131 | 99h 46m | 57m |
| Pipe pulling tonal | 70 | 14h 37m | 33m |
| Impulsive sequence | 25 | 18h 43m | 42m |
| Aircraft | 8 | 8m 37s | 1m 5s |

The next section describes each noise class, with three representative examples shown in spectrogram figures. The spectrogram images and equivalent audio files for all these noise examples can be downloaded from this url:
https://drive.google.com/open?id=1D-DCZnzau5DKaSgC_odzk_XBsxYUh6vB

### 3.3.1 Vessel noise

This class included engine and propeller noise from vessels. It was the most prevalent source of noise from all identified classes. Its presence was constant from the first recordings of the initial day of the deployment on May 5th 2018, and persisted throughout the deployment. Vessel noise impeded the use of the initial deployment days as baseline noise conditions, as it was initially planned. Based on the time periods of all events logged for this class, median SPL was 121.9 dB, mean was 120.7 dB (stdv of 5.9 dB). Based on these received levels, and assuming practical spreading, this noise source did not exceed the level B threshold at the 2.7 km isopleth distance. Examples of vessel noise events are shown in Fig. 9.



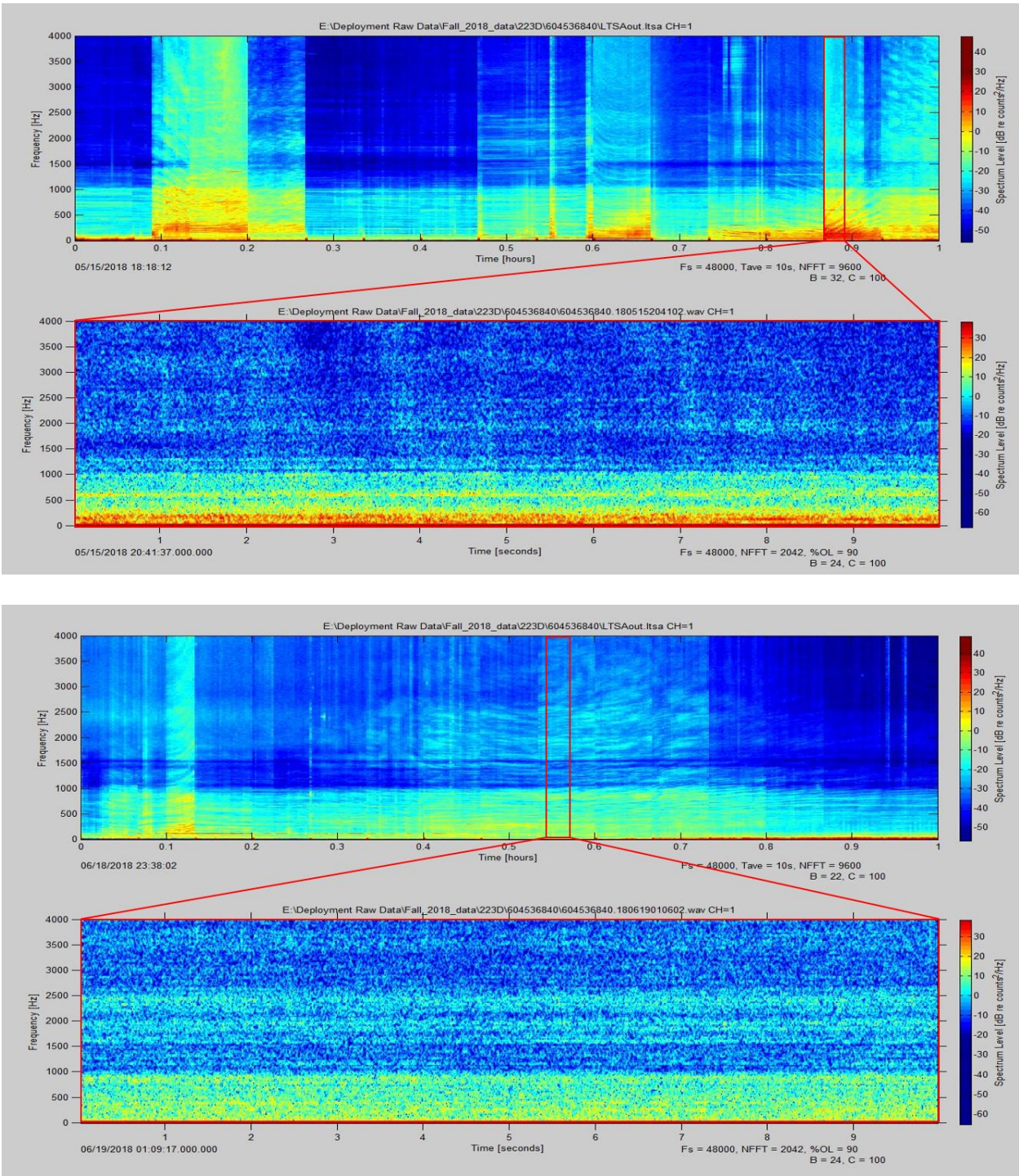
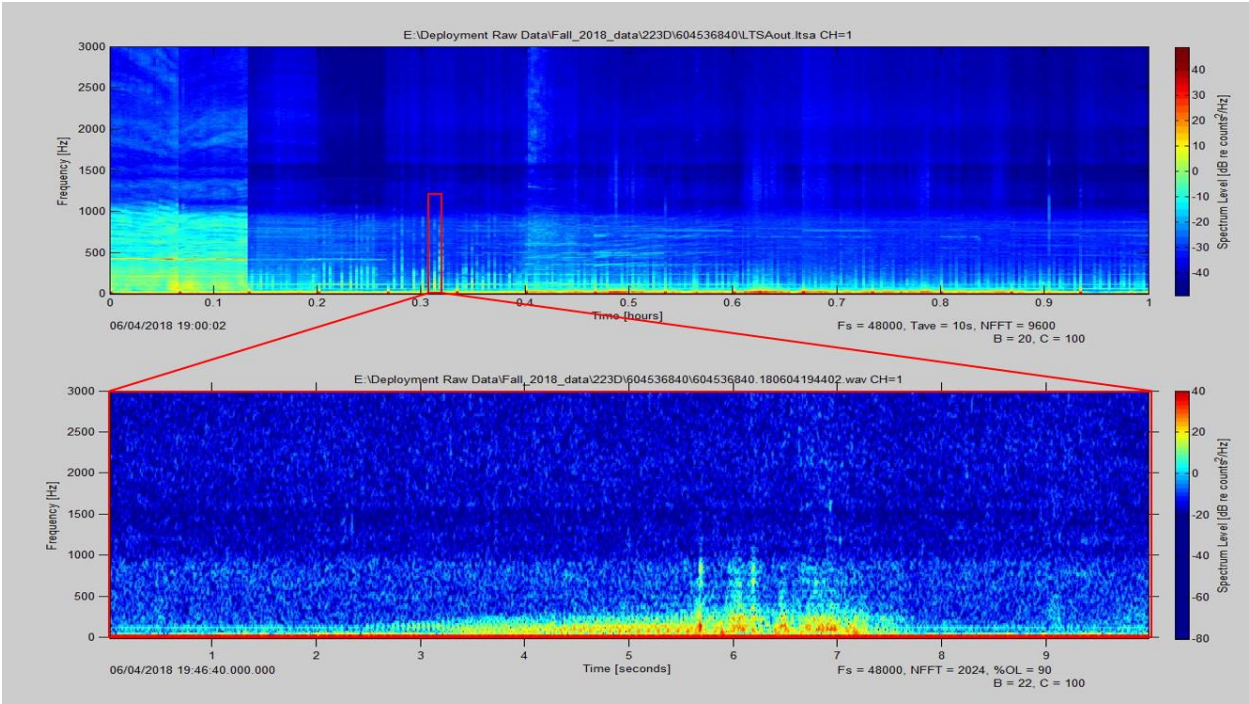



Figure 9: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 10 s spectrogram (lower panel) of typical vessel noise.

### 3.3.2 Unknown

This was the second most recurrent noise source. The origin is mechanical and likely related to some of the operations in the area, but it was not possible to assign any specific source. Low frequency in nature, up to 1 kHz but sometimes exceeding 2 kHz. Its occurrence was not associated to any single other source of noise. Based on the time periods of all events logged for this class, median SPL was 116.1 dB, mean was 116.3 dB (stdv of 1.5 dB). Based on these received levels, and assuming practical spreading, this noise source did not exceed the level B threshold at the 2.7 km isopleth distance. Examples of unknown noise events are shown in Fig. 10.



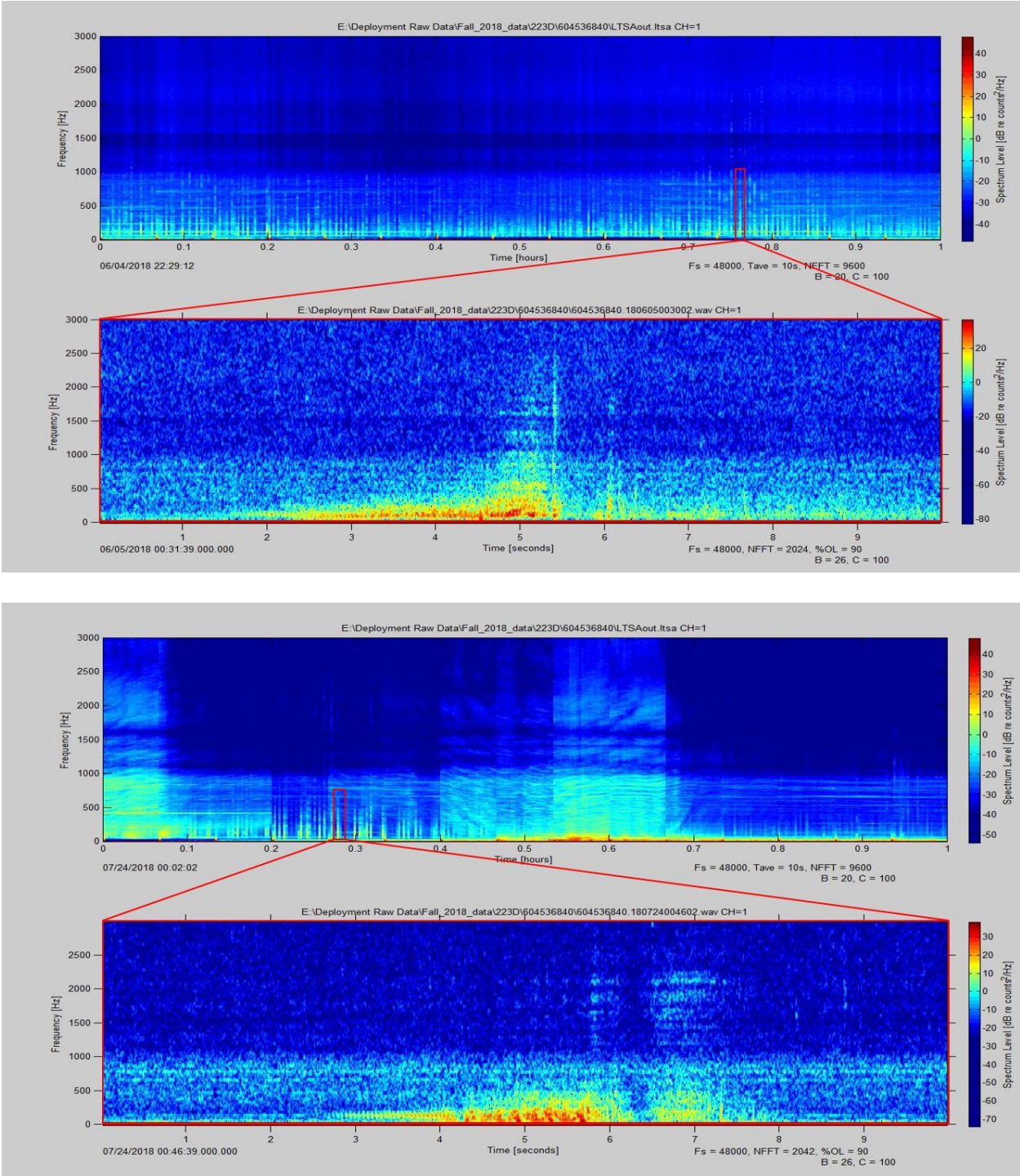
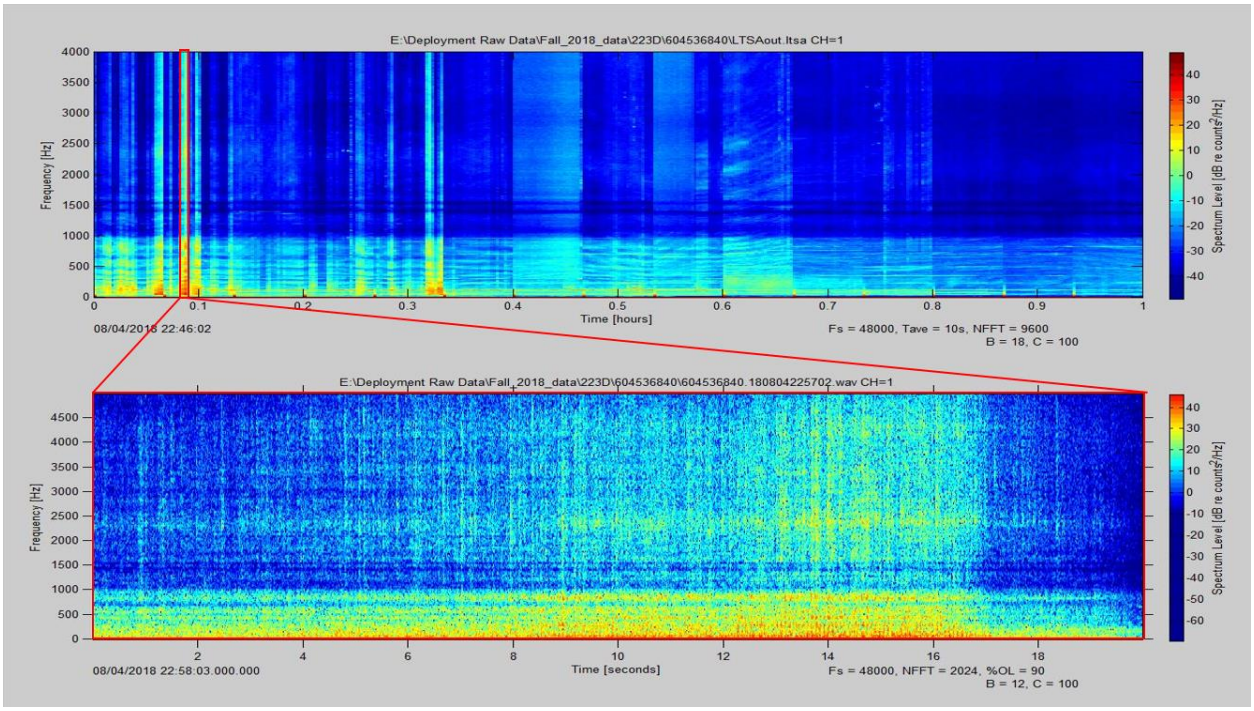



Figure 10: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 10 s spectrogram (lower panel) of typical unknown noise.

### 3.3.3 Pipe pulling impulsive

This was an identifiable signal often occurring within periods when pipe pulling tonal noise was detected. Time periods corresponding with this noise class often occurred within pipe pulling operational context in Appendix F. the rattling nature of this signal resembles propeller cavitation. Based on the time periods of all events logged for this class, median SPL was 132.7 dB, mean was 130.3 dB (stdv of 5.9 dB). Based on these received levels, and assuming practical spreading, this noise source exceeded the level B threshold at the 2.7 km isopleth distance. Examples of unknown noise events are shown in Fig. 11.



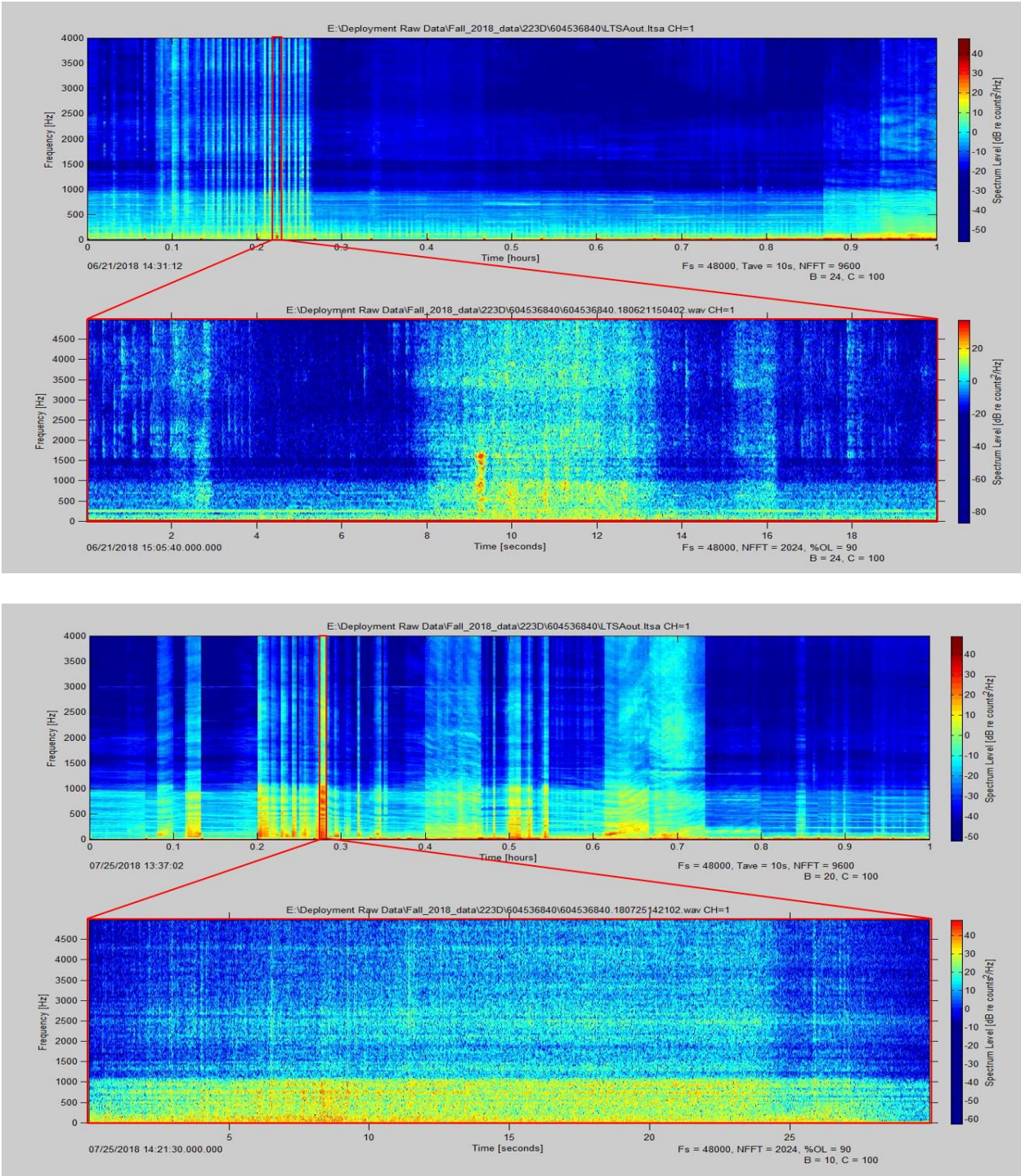
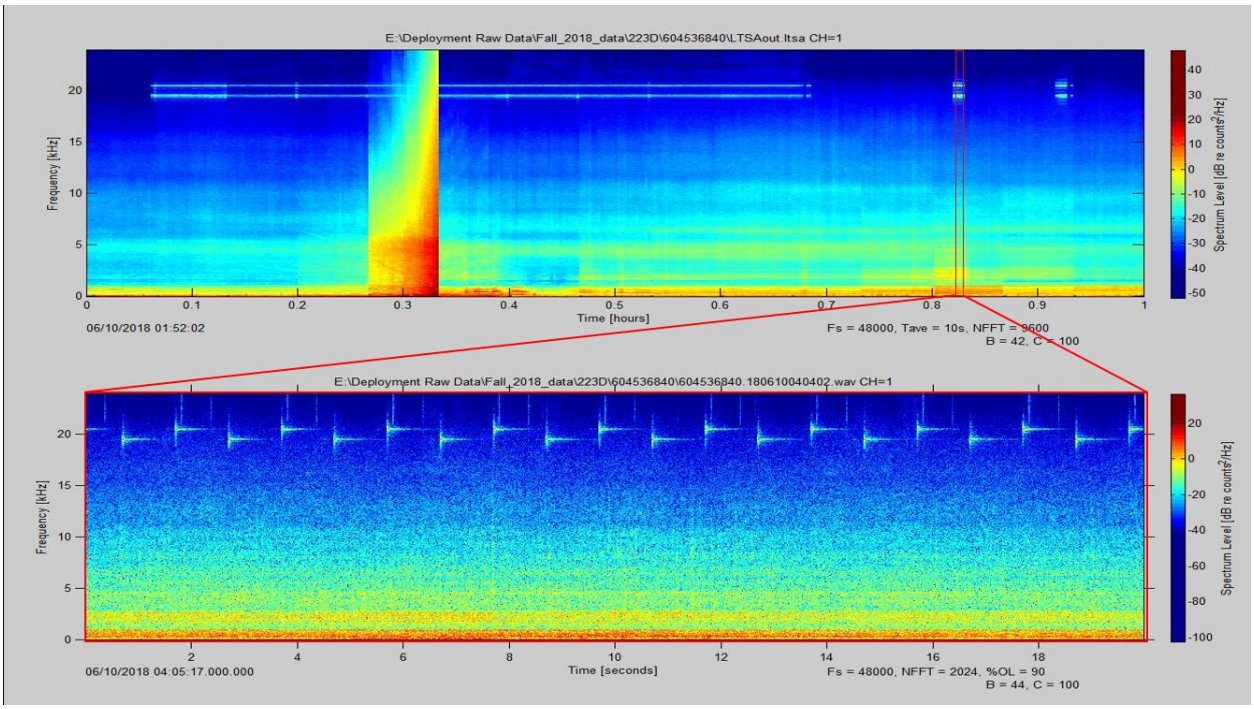



Figure 11: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 20 s spectrogram (lower panel) of typical pipe pulling impulsive noise.

### 3.3.4 Pinger 20 kHz

This pinger signal occurred between 5/16/18 and 9/13/18. The signal was emitted in sequences alternating two peak frequencies, 19.5 kHz and 20.5 kHz, at 1-second intervals, but sometimes with only the upper frequency in the series. Because of the narrowband nature of this signal, SPL was measured on a 200 Hz band centered in 19.5 and 20.5 kHz. Based on the time periods of all events logged for this class, median $SPL_{20.5}$ was 94.8 dB, mean was 92.1 dB (stdv of 7.4 dB), and $SPL_{19.5}$ was 96.1 dB, mean was 93 dB (stdv of 5.9 dB). When these levels are compared to the background noise levels for these same frequency bands but before or after the pinger sequences, the pinger signal exceeds background noise in 30 to 43 dB.
Examples of the 20 kHz pinger noise events are shown in Fig. 12.



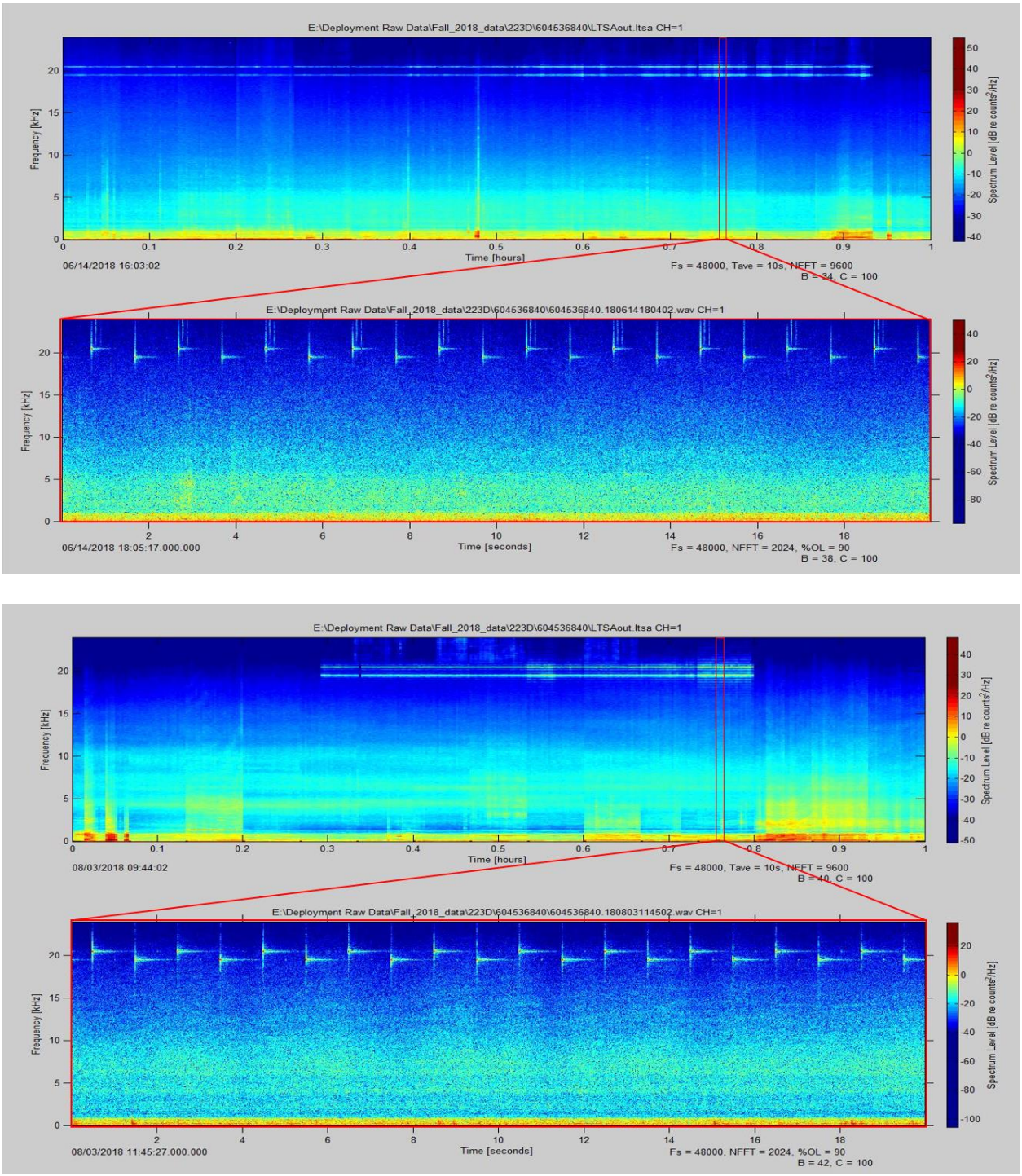
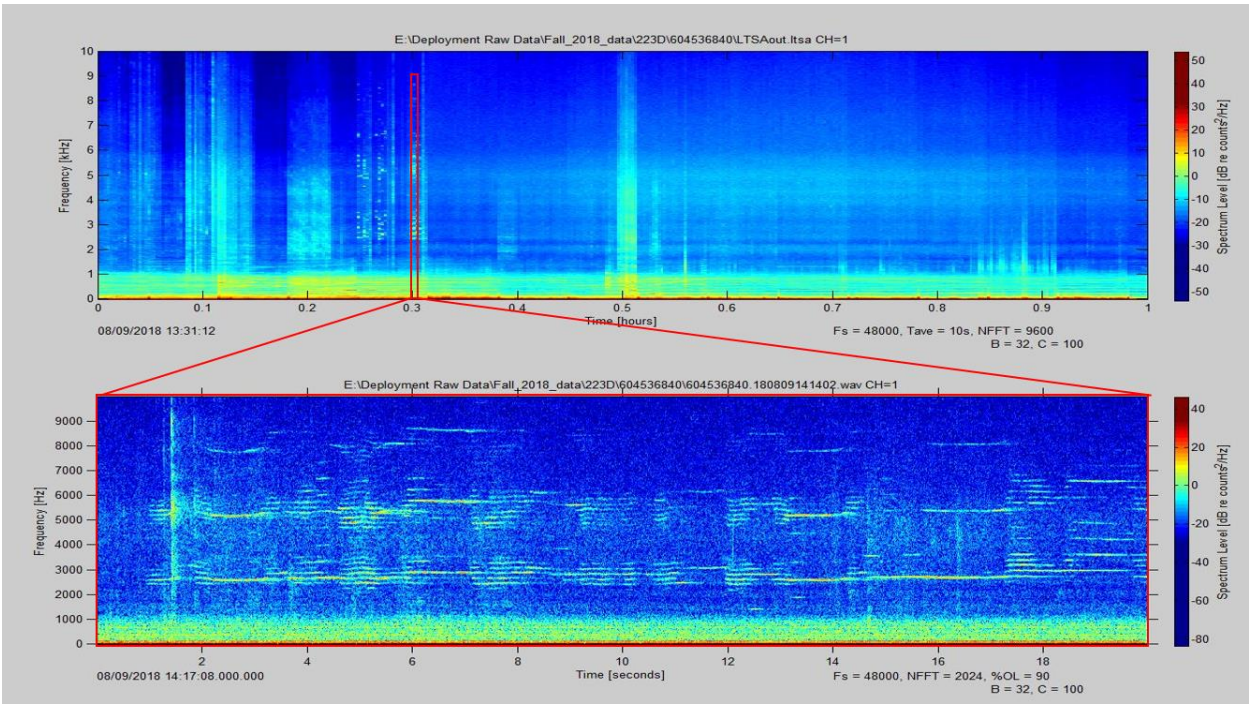



Figure 12: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 20 s spectrogram (lower panel) of typical 20 kHz pinger noise.

### 3.3.5 Pipe pulling tonal

This was a very identifiable signal, mainly occurring within periods of pipe pulling operational context in Appendix F, but for several events also in the category anchor handling and other. Flat tonal bands at different frequencies, up to 8.5 kHz, were produced by some type of hydraulic machinery, likely related to the winch operation. These tonal components were also identified in video footage made by Sheyna Wisdom on 6/14/18 onboard the winch barge while winching the 8-inch pipe from the center winch. Based on the time periods of all events logged for this class, median SPL was 122.9 dB, mean was 123.1 dB (stdv of 6.8 dB). Based on these received levels, and assuming practical spreading, this noise source did not exceed the level B threshold at the 2.7 km isopleth distance. Examples of pipe pulling tonal noise events are shown in Fig. 13.



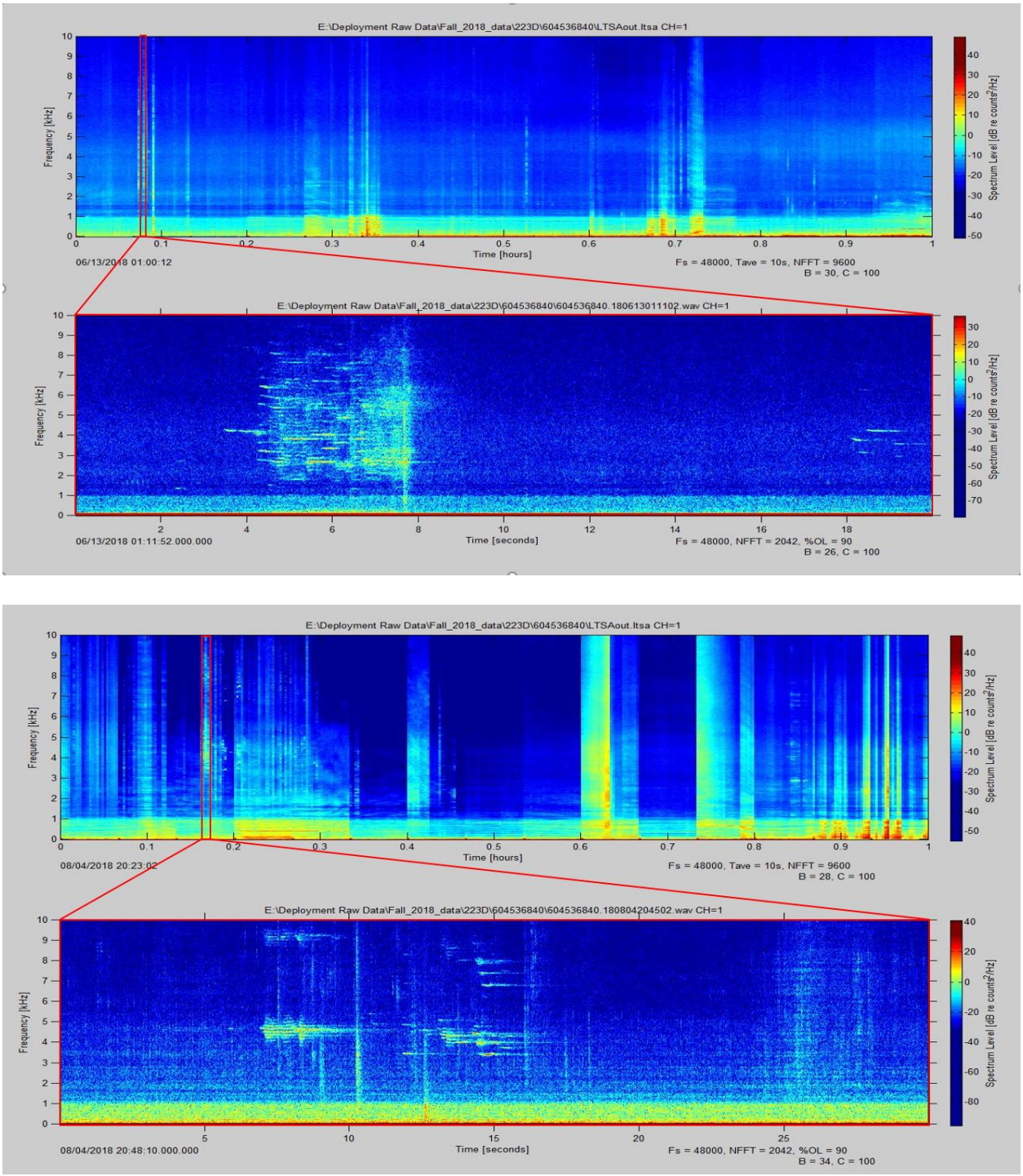



Figure 13: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 20 s spectrogram (lower panel) of typical pipe pulling tonal noise.

### 3.3.6 Impulsive sequence

This was an easily identifiable signal occurring in long sequences. Its occurrence was not clearly related to any of the operational contexts from Appendix F, and further evaluation by Fairweather suggested this signal occurred during times of no work. Date and times of occurrence were compared to tidal cycle (Fig. 14) and results clearly suggest this source of noise is related to high peaks in current during the ebbing tidal cycle.

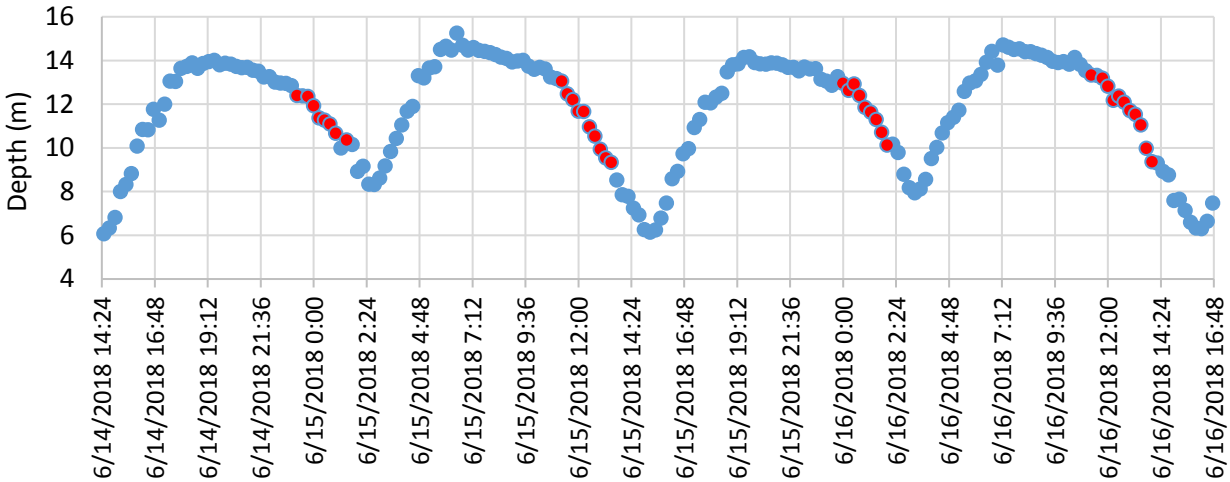
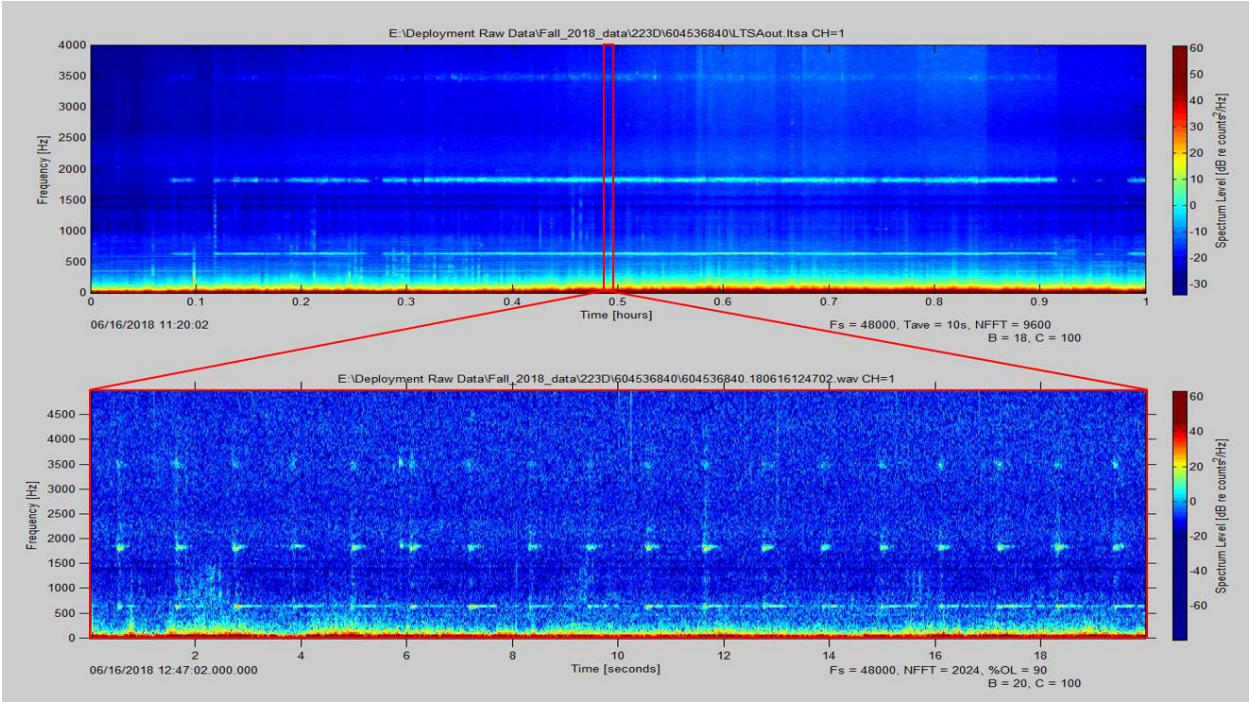
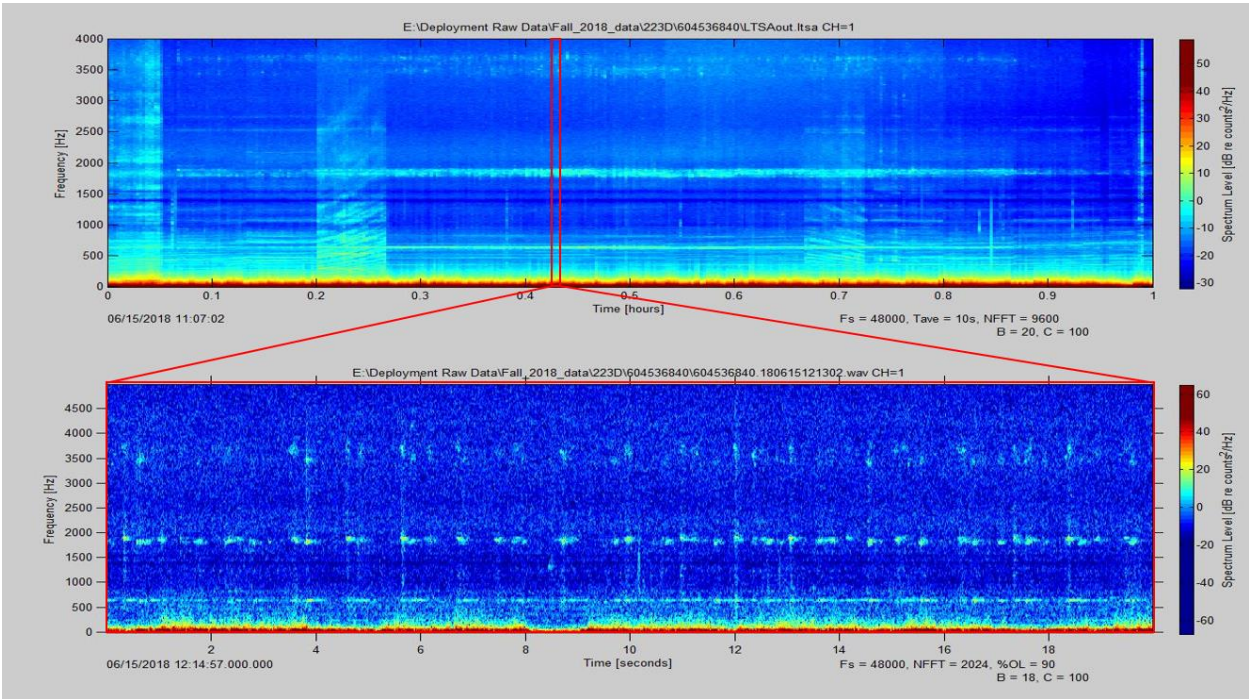



Figure 14: Depth variation due to tidal effect at the mooring location from 6/14/18 at 14:24 to 6/16/18 at 16:48 (4 full tidal cycles), and presence (red) and absence (blue) of the impulsive sequence noise, showing a clear relationship with the period of peak current during the ebb tide.

Two potential sources for this noise are speculated. One is at "Tyonek" platform, where an ice protection structure in one of the platform legs was not completely welded to the leg at the time of the pipe laying operation, and could be banging against the leg on high current periods. However, the platform is 6.4 km away from the mooring. A second possibility could be related to the winch barge anchor lines. The winch barge is anchored with a set of 6 anchors. The anchor lines are composed of 4.6 m (15 ft) of chain and 1,280 m (4,200 ft) of wire cable, and each anchor also has a surface buoy line for the tug boats to handle the anchors (Sitkiewicz *et al*. 2018). Some of these lines could easily strum during high current periods, and the strumming action could force any elements of the lines (shackles, chain, etc.) to bang against metal surfaces at the anchor connection point. The most plausible cause of this noise, based on the information collected by Fairweather on anchors, is that the chain connecting the anchor to the surface buoy line could bang against the anchor. Reviewing the dates when this noise was detected, it was found that the winch barge was always working in the 1.5 - 4 km from shore distance. In this segment of the pipe path, some of the barge anchors would be closest to the acoustic mooring. Based on the time periods of all events logged for this class, median SPL was 144.7 dB, mean was 145.4 dB (stdv of 2 dB). Based on these received levels, and assuming

practical spreading, this noise source exceeded the level B threshold at the 2.7 km isopleth distance (however this is based on the source located at the winch barge, which is further distance than if this source is originated at the anchors). Examples of impulsive sequence noise events are shown in Fig. 15.



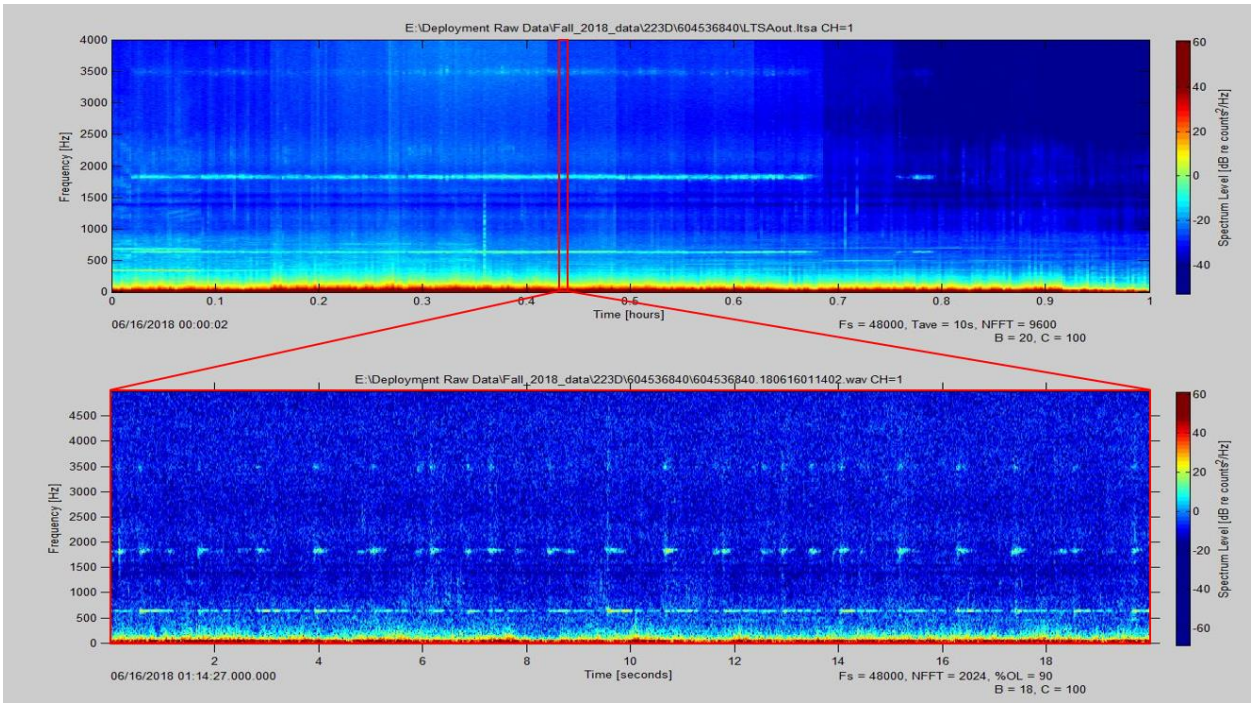
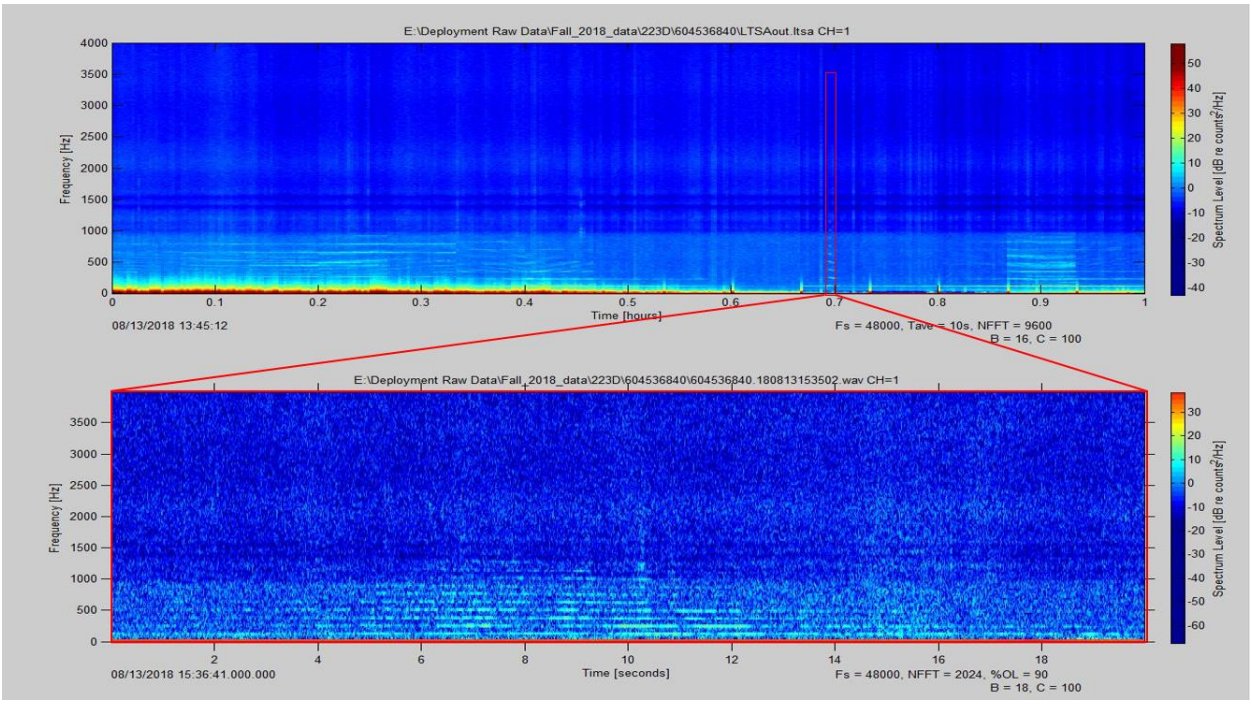
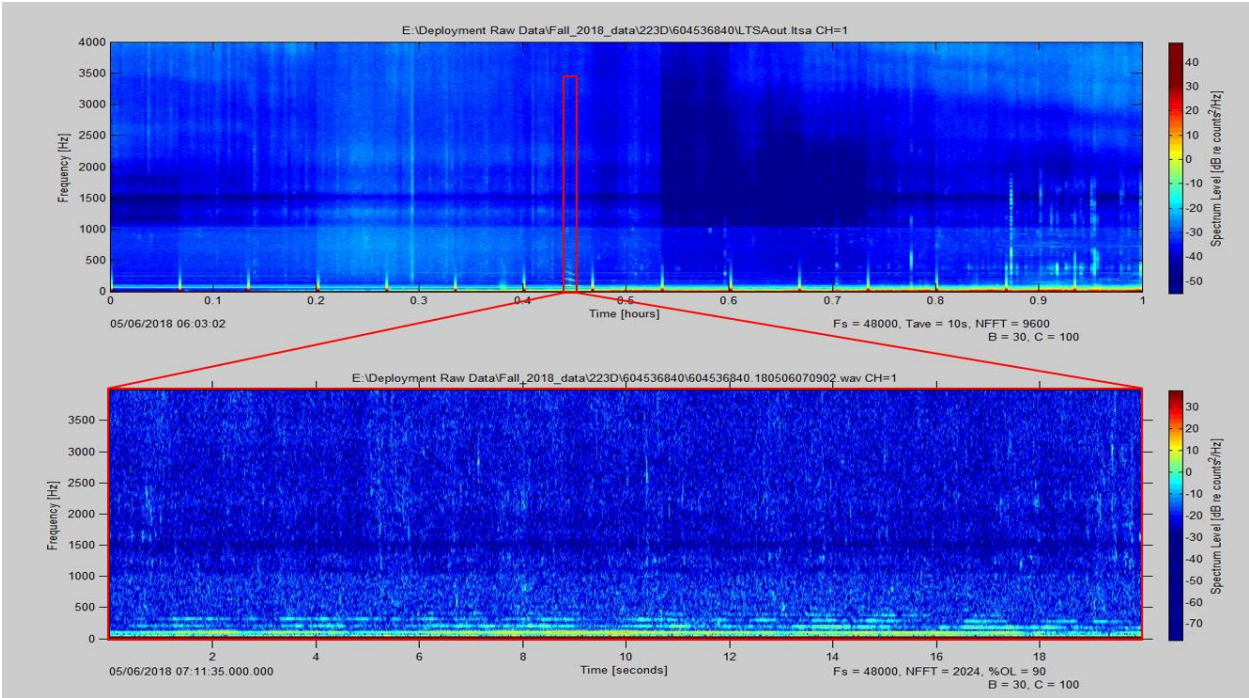


Figure 15: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 20 s spectrogram (lower panel) of typical impulsive sequence noise.

### 3.3.7 Aircraft

These are short low frequency events, unrelated to the pipe laying activity, but are included here to provide context of other sources of noise identified in this study. Only 8 events were identified, likely all are single propeller airplanes flying at low altitude over the mooring location. Main frequencies affected are below 1 kHz, and the duration of this disturbance is below 1 minute. Based on the time periods of all 8 events logged for this class, median SPL was 131.8 dB, mean was 127.1 dB (stdv of 9 dB). Evaluating if this source exceeded level B at the 2.7 km isopleth distance makes no sense as this source was unrelated to the pipe-laying project. Examples of aircraft noise events are shown in Fig. 16.


E:\Deployment Raw Data\Fall_2018_data\223D\604536840\LTSAout.ltsa CH=1
Frequency [Hz]
Time [hours]
Spectrum Level [dB re counts²/Hz]
08/13/2018 13:45:12
Fs = 48000, Tave = 10s, NFFT = 9600
B = 16, C = 100
E:\Deployment Raw Data\Fall_2018_data\223D\604536840\604536840.180813153502.wav CH=1
Frequency [Hz]
Time [seconds]
Spectrum Level [dB re counts²/Hz]
08/13/2018 15:36:41.000.000
Fs = 48000, NFFT = 2024, %OL = 90
B = 18, C = 100


E:\Deployment Raw Data\Fall_2018_data\223D\604536840\LTSAout.ltsa CH=1
Frequency [Hz]
Time [hours]
Spectrum Level [dB re counts²/Hz]
05/06/2018 06:03:02
Fs = 48000, Tave = 10s, NFFT = 9600
B = 30, C = 100
E:\Deployment Raw Data\Fall_2018_data\223D\604536840\604536840.180506070902.wav CH=1
Frequency [Hz]
Time [seconds]
Spectrum Level [dB re counts²/Hz]
05/06/2018 07:11:35.000.000
Fs = 48000, NFFT = 2024, %OL = 90
B = 30, C = 100

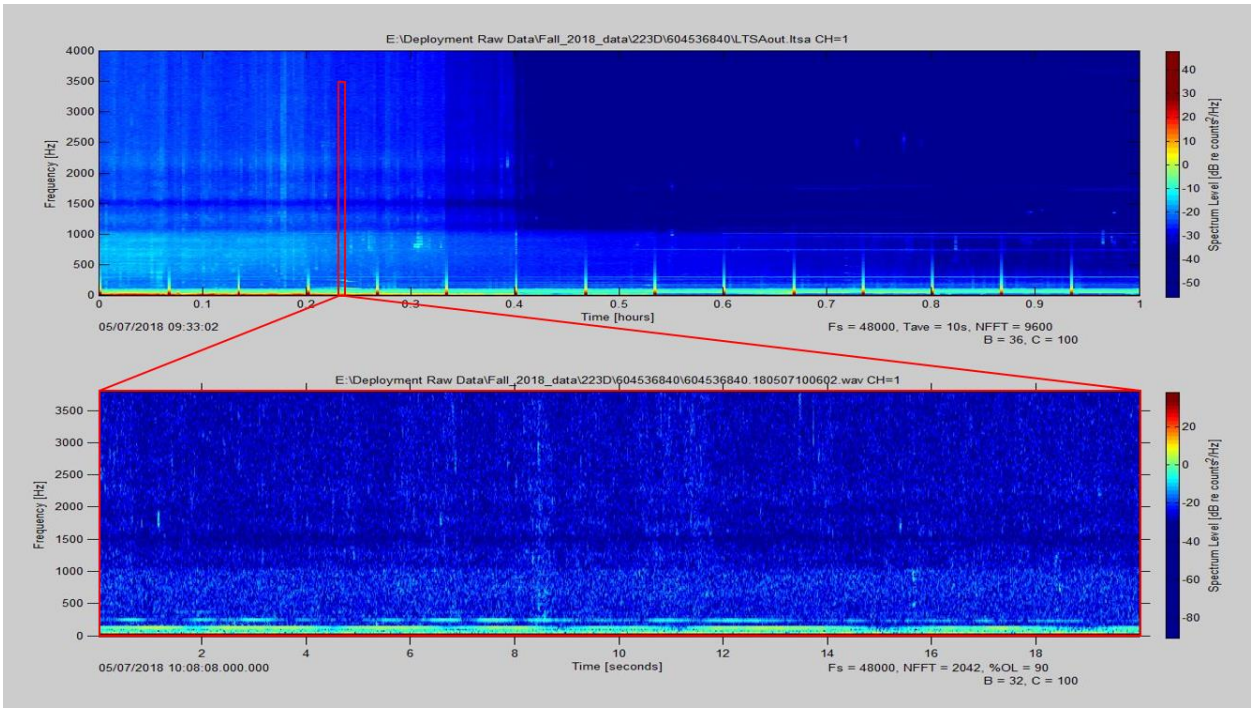



Figure 16: Three examples of a long-term spectrogram (upper panel) with 1 h of data (corresponding to 2h and 45 m of time), and 10 s spectrogram (lower panel) of typical aircraft noise.

## 3.4 Source level calculations

Source level (SL) requires knowing the received level and the distance from the mooring to the source when the signal was produced because transmission loss is directly dependent on the distance traveled by sound from the source to the receiver. Accurate locations of the winch barge were not available, but locations of the vessel “Sand Island”, operating side scan sonar when the pie was being pulled by the winch barge, was used as proxy for barge location. The GPS location data from this vessel was widespread, and not easy to identify clear sequential movements along the pipe path (Fig. 17). Locations of this vessel were plotted in different ways to attempt to identify movement patterns. Using the 12pm location for each day seemed the best approach to clarify movement along the pipe path (Fig. 18). Once periods of closest proximity to the mooring were identified, and noise events selected, the vessel location at the specific date and times were used to calculate distances to the mooring.

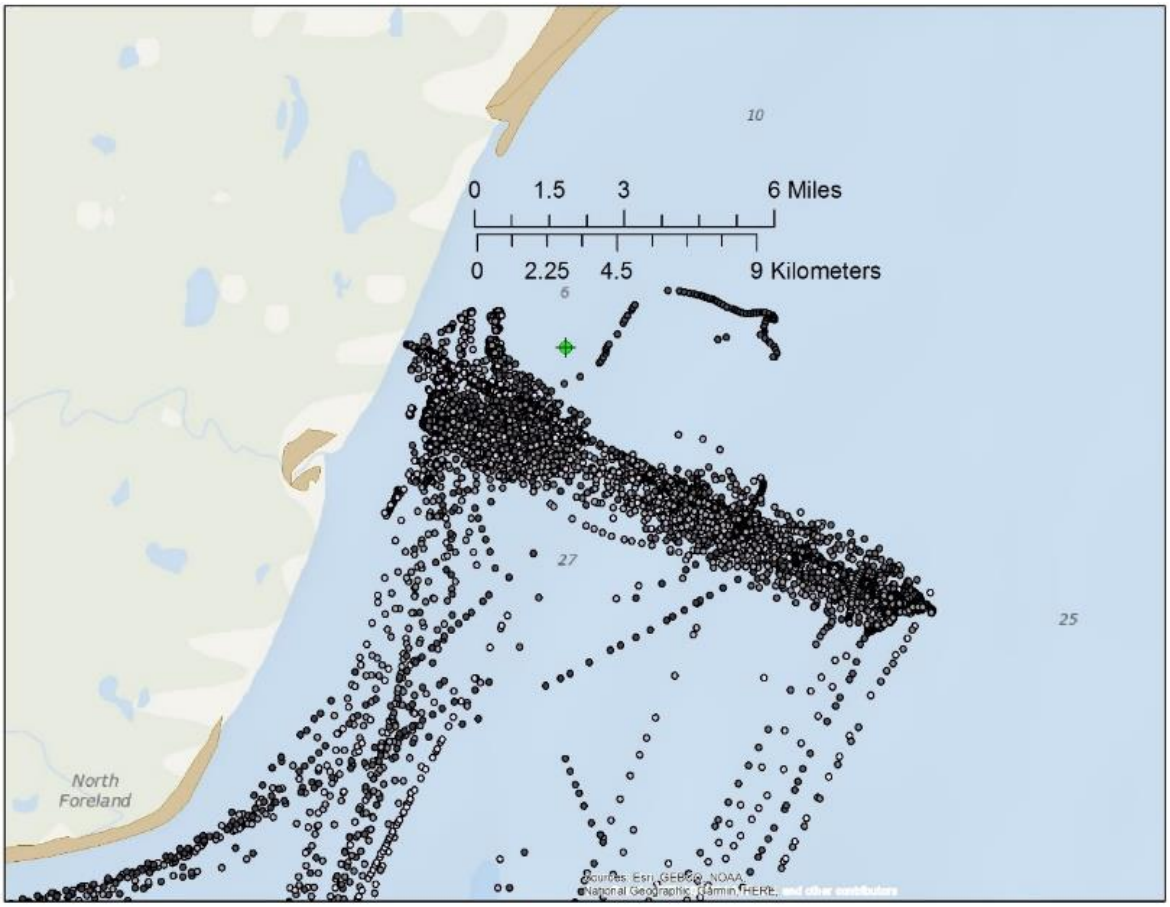



Figure 17: GPS locations for the vessel “Sand Island” from 5/14/18 to 9/13/18, as proxy for the winch barge location. Green dot denotes the acoustic mooring location.

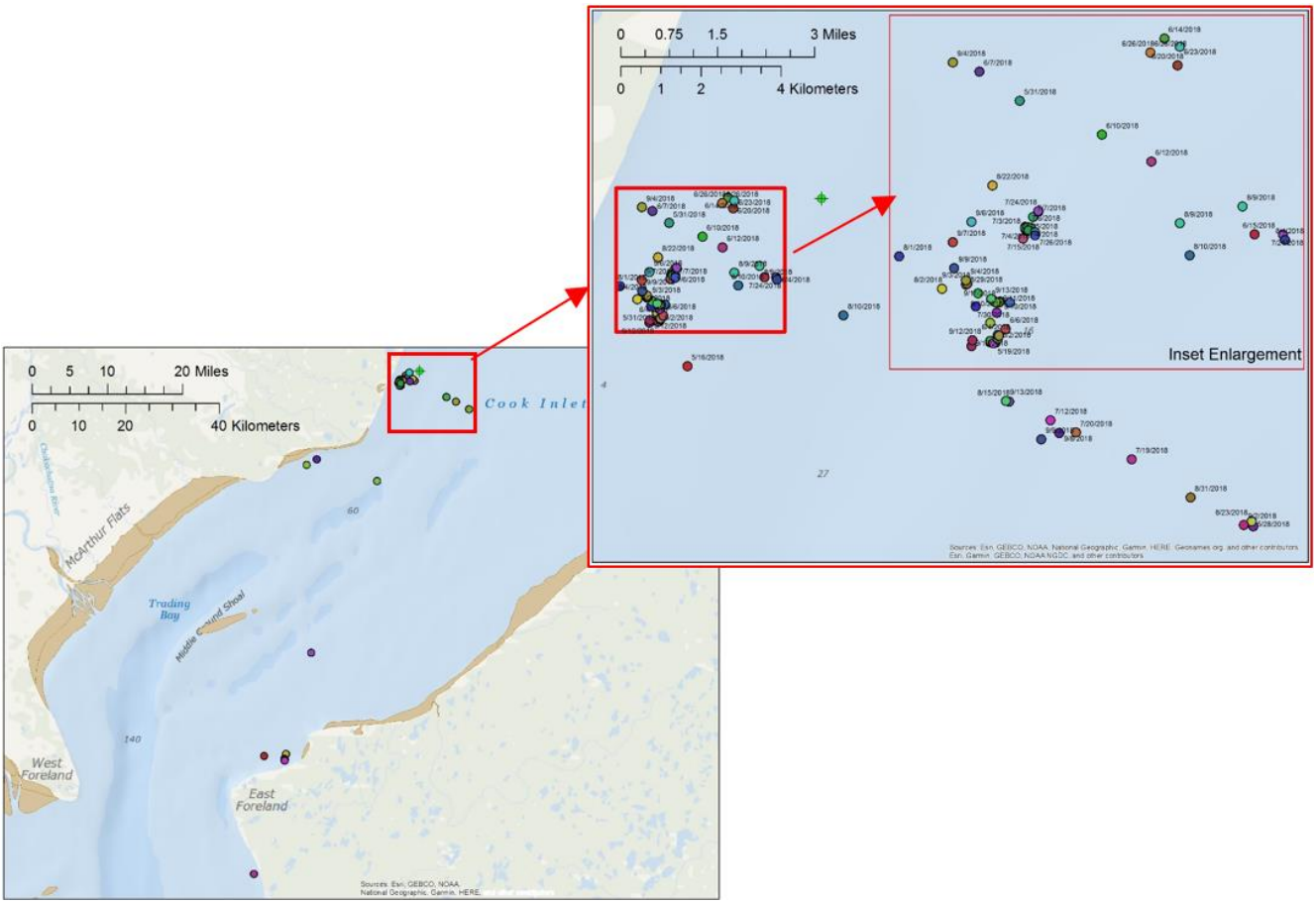



Figure18: Colored dots represent the GPS locations at 12:00pm local time for the vessel "Sand Island" from 5/14/18 to 9/13/18, as proxy for the winch barge location. Colored dots are accompanied with the date of the GPS location. Green crossed dot denotes the acoustic mooring location.

Based on shortest distance to the acoustic mooring, daily operations from Appendix F, operations summary provided by Jaclyn Daly, and highest number of identified noise events for each class, four different days were chosen to calculate source levels (Fig. 19). These dates were:

6/10/18 – 3.12 km from mooring: when operations occurred in the nearshore work zone (0-2 km from shore). Operations included anchor handling to move the pipe, pull barge, and pipeline pulling. Other operations included sandbagging the pipeline after it was deployed and general maintenance of the existing pipeline by the dive support vessels.

6/15/18 – 2.42 km from mooring: when anchor handling tugs worked in the middle work zone (2-6.5 km from shore), and other vessels were in the nearshore work zone supporting the pipe pulling. Operations included anchor handling to move the pipe, pull barge, and pipeline pulling.

Other operations included sandbagging the pipeline after it was deployed and general maintenance of the existing pipeline by the dive support vessels.

8/4/18 – 2.3 km from mooring: when anchor handling tugs worked in the middle zone. Operations included anchor handling to move the pipe, pull barge, and pipeline pulling. Other operations included clock spring remediation, stabilizing the pipeline with sandbags, attempts to raise the pipeline, torqueing, and general maintenance of the existing pipeline by the dive support vessels.

8/9/18 – 2.28 km from mooring: same general area and operations as in 8/4/18.

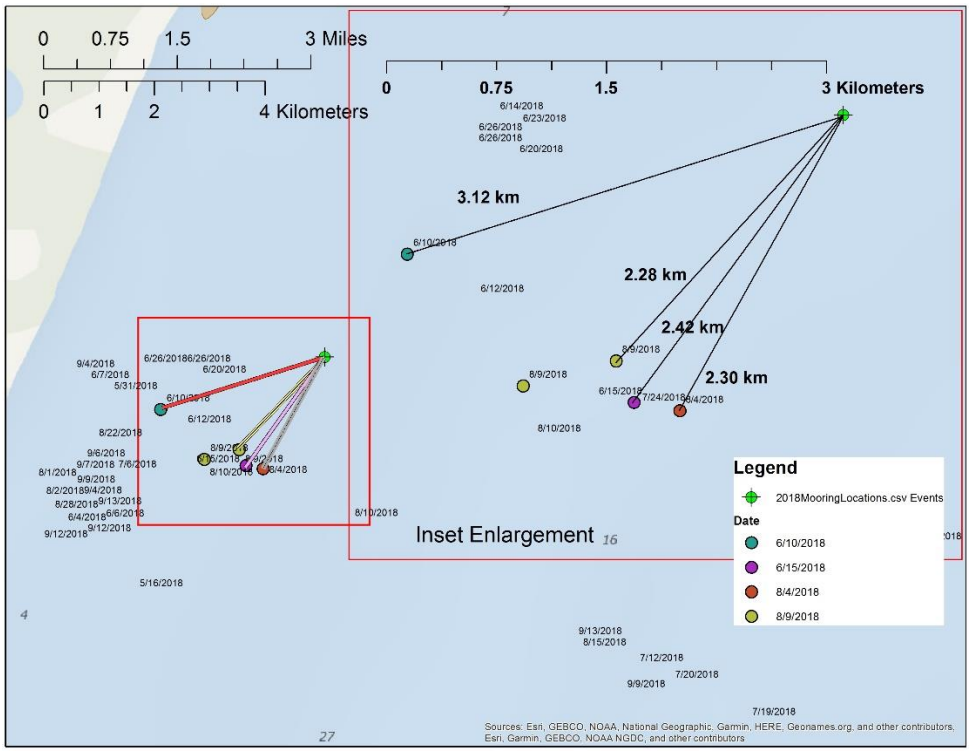



Figure 19: GPS locations at 12:00pm local time for the vessel "Sand Island" as proxy for the winch barge location, for the selected 4 days to calculate SLs of all noise classes identified in the study. Green crossed dot denotes the acoustic mooring location.

From the 7 noise classes identified in this study, SLs were calculated for 4 classes. Aircraft was excluded, as there is no way to obtain location of the source. Vessel noise was excluded as there were multiple vessels in continuous movement within the study area, and thus it would be unrealistic to assume received vessel noise was originated only from "Sand Island". Unfortunately, none of the unknown class events that were detected on these 4 days were clean enough (non-overlapped with other sources of noise, good SNR) to allow measuring RLs. The range of obtained SLs for each noise class measured are summarized in table 3.

All source levels were calculated when the source of noise was at a maximum of 3.12 km (6/10/18) from the mooring. This spatial context reduces the potential effect of flow noise during peak current periods as the received levels are expected to be of high amplitude, and thus any flow noise contribution within the frequencies of interest would be masked by the source noise.

Table 3: Noise class and RL range obtained from the 4 days where source location was identified and distance to mooring was measured.

| **Noise class** | **Source of noise** | **Source level (RMS dB re 1µPa 20 Hz - 24 kHz)** | **Notes** |
|---|---|---|---|
| Aircraft | Aircraft engine in air | n/a | |
| Commercial Ship | Engine and propeller cavitation | n/a | |
| Impulsive sequence | Chain from marker buoy hitting the anchor | 191.8 to 195.3 | Assuming source is at winch barge* |
| Impulsive sequence | Ice protection in platform leg | 200.9 to 204.6 | Assuming source is at “Tyonek” platform |
| Pinger 20kHz | Pinger transducer | 138.6 to 149.1 | 200 Hz band centered at 19.5 kHz |
| Pinger 20kHz | Pinger transducer | 136.1 to 150.1 | 200 Hz band centered at 20.5 kHz |
| Pipe pulling tonal | Winch hydraulic system | 174.5 to 175.3 | Pipe pulling periods were characterized by this and the impulsive noise in next row |
| Pipe pulling impulsive | Pipe dragged on seafloor | 173.9 to 183.1 | Often occurring in a well-defined sequence |
| Unknown | | n/a | |

* It should be noted that the distance to the source is based on the GPS location of the vessel “Sand Island” as a proxy for the winch barge. However, if this source of noise is at the barge anchors, these were closer in distance to the mooring than the barge, and thus these SLs might be an overestimation. Distance from nearest anchor to the mooring, for the date and time of each impulsive sequence event, was not available.

Because of the narrowband nature of the 20 kHz pinger, the 200 Hz band SPL values were compared to the same 200 Hz band just before and after the ping signals to provide a comparison with baseline noise levels. For the 19.5 kHz band, the ping signal was a median of 35 dB above baseline, and for the 20.5 kHz band, the ping was a median of 35.2 dB above baseline.

It should be noted that we avoided using overlapping events to calculate received and source levels when possible. For example, pipe pulling and impulsive sequence events that overlapped with pinger signals were excluded in the analysis of received and source levels. However, ship noise was present almost continuously and thus it was impossible to avoid its overlap in the selection of events from other sources. In those cases, only events whose noise levels where of higher amplitude than the background ship noise were used in the calculations.

## 3.5 Comparison of beluga visual sightings with acoustic detections

Visual effort days and their respective start/end times were compared to acoustic data to identify sightings associated to acoustic detections. A buffer time of 5 minutes around the sighting, time was used to find acoustic detections, to account for behavioral effects (i.e., belugas might not be vocalizing at the exact time of sighting but might be soon before or after).

The period 5/9/18 to 9/13/18 included concurrent visual and acoustic effort (total of 128 days). All days with sightings included acoustic detections except 3 (2.3 %), while 28 days (21.3%) with acoustic detections did not include visual observations. Based on concurrent visual and acoustic detections falling into 27 different visual effort grid cells, maximum acoustic detection range from the mooring was estimated at 6.7 km for vocalizations and 2.4 km for echolocation (Fig. 20). Acoustic detections without corresponding visual sighting could be explained, in part, by the larger acoustic detection range, exceeding the visual effort grid cell.

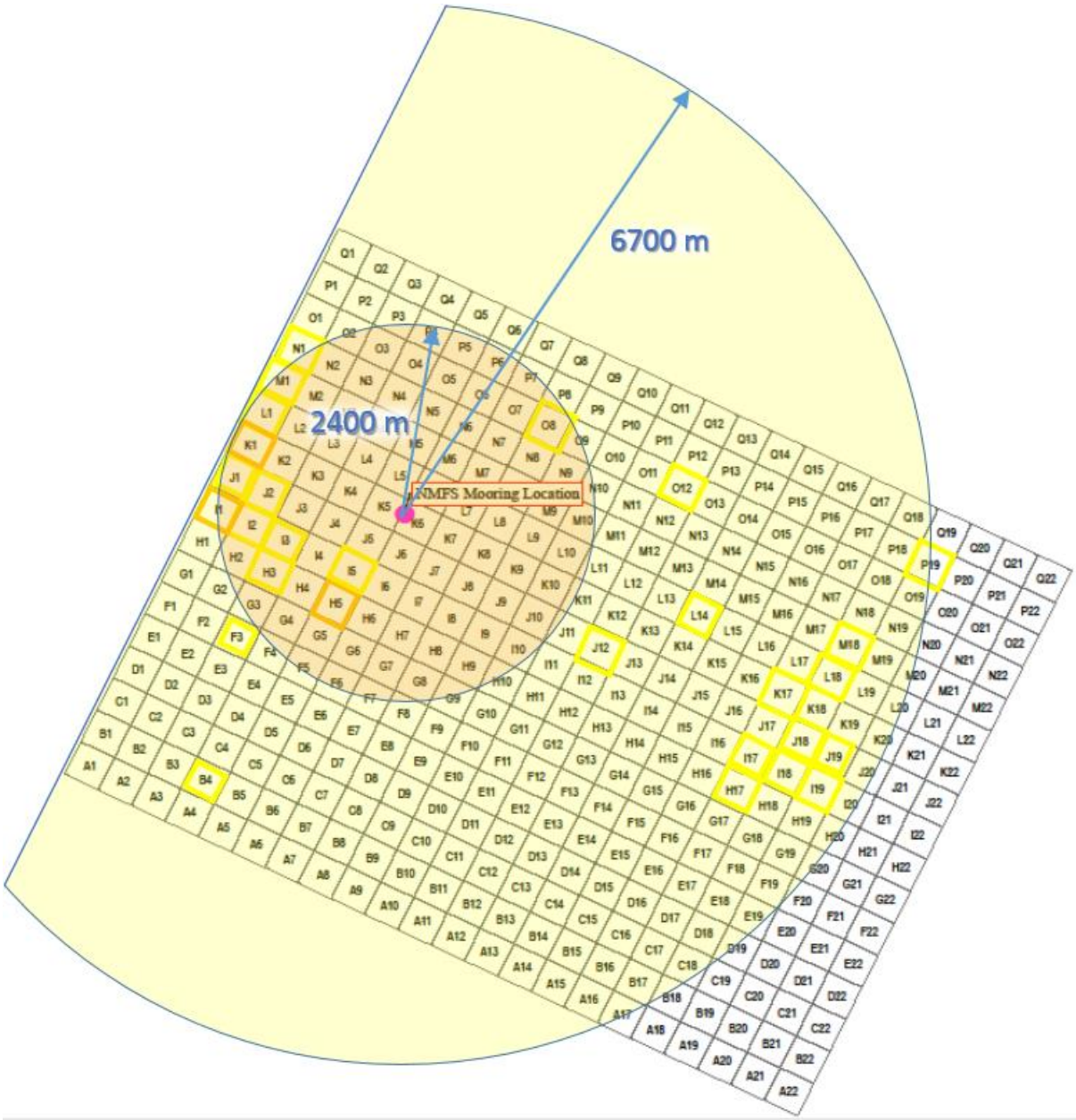



Figure 20: Visual effort grid cell with location of acoustic mooring (pink dot). Concurrent visual and acoustic detections occurred in yellow cells (only calls) and orange cells (calls and echolocation). Maximum detection range for echolocation (2400 m) and for calls (6700 m) is calculated from mooring to center of these grid cells.

## 3.6 Harbor porpoise detections

The C-POD instrument also logged harbor porpoise detections throughout the deployment period. Detection range for this species is known to be shorter, approximately 400 m (Chelonia Ltd. 2014) as these are high frequency signals centered in the 130-140 kHz frequency range, and thus affected by stronger transmission loss.

Porpoises were detected from May 5th 2018 to September 10th 2018, with a maximum of 10 detection positive minutes (DPM) on June 14th 2018 (Fig. 21)

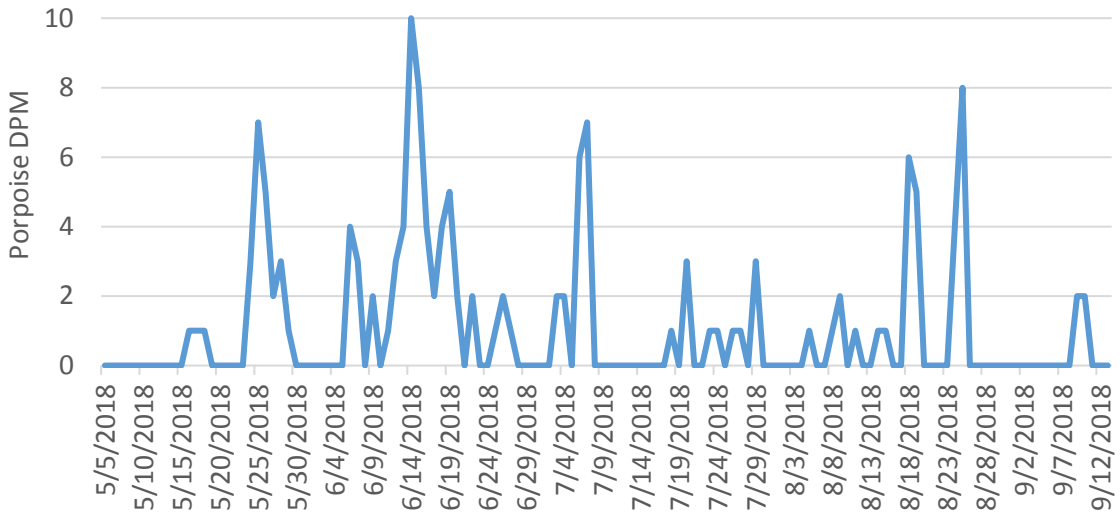



Figure 21: Harbor porpoise detections presented as detection positive minutes (DPM) per day for the deployment period May 5th 2018 to September 13th 2018.

There was a total of 29 harbor porpoise sightings reported by the visual effort, 5 from the platform and 24 from Ladd Landing (Sitkiewicz et al. 2018). Dates of sightings were compared to dates of acoustic detections, and from the 18 days with sightings, 8 had acoustic detections (44.4% of dates). This lower overlap is expected, as the detection range for this species is short, thus porpoises sighted in areas far from the mooring location might never yield acoustic detections. When acoustic detections that occurred within visual effort times where compared to sighting dates, a total of 21 days included detections that were not matched with visual sightings. This reflects the visually cryptic nature of porpoises.

# 4. References

Castellote M, Small R, Lammers MO, Jenniges J, Mondragon J, Atkinson S. 2016. Dual instrument passive acoustic monitoring of belugas in Cook Inlet, Alaska. Journal of the Acoustical Society of America 139(5): 2697–2707. https://doi.org/10.1121/1.4947427

Chelonia Ltd. 2014. C-POD specification. https://www.chelonia.co.uk/cpod_specification.htm

Merchant ND, Barton TR, Thompson PM, Pirotta E, Dakin DT, Dorocicz J. 2013. Spectral probability density as a tool for ambient noise analysis. Journal of the Acoustical Society of America Express Letters 133: EL262−EL267. http://dx.doi.org/10.1121/1.4794934

Sitkiewicz S, Hetrick W, Leonard K, Wisdom S. 2018. 2018 Harvest Alaska Cook Inlet Pipeline Project Monitoring Program Marine Mammal Monitoring and Mitigation Report. Prepared for Harvest Alaska, LLC, 3800 Centerpoint Drive, Suite 1400, Anchorage, Alaska 99503 Submitted to National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, 1315 East West Highway, Silver Spring, MD 20910. Prepared by Fairweather Science, 301 Calista Court, Anchorage, AK 99518. November 26, 2018.